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Effect of Increased Winter Drawdown on Benthic Macroinvertebrates in Namakan Reservoir, Voyageurs National Park

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WATER RESOURCES DIVISION
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EFFECT OF INCREASED WINTER DRAWDOWN ON BENTHIC MACROINVERTEBRATES IN NAMAKAN RESERVOIR, VOYAGEURS NATIONAL PARK

by Kenneth J. Kraft
Michigan Technological University
Houghton, Michigan 49931

NATIONAL PARK SERVICE - Midwest Region

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ABSTRACT

The effect of increased winter drawdown on benthic macroinvertebrtates in Namakan Reservoir, Voyageurs National Park, was studied by comparing invertebrate samples from Reservoir locations with those from Rainy Lake which had little drawdown. During the three years of the study, drawdown averaged 2.5 meters in the Reservoir and 1.1 meters in Rainy Lake. Macroinvertebrates collected at depths of 1, 2, 3, 4 and 5 meters at three Reservoir locations were compared with those collected at two locations in Rainy Lake. Dead, stranded invertebrates were commonly found in the Reservoir during winter drawdown. One taxon, the isopod genus *Asellus*, was common in Rainy Lake but absent from Reservoir samples. Five other taxa, *Caenis*, *Chaoborus*, Gastropoda, *Hexagenia* and *Sialis*, showed marked reductions in density in the Reservoir locations compared to Rainy Lake locations. Invertebrate density showed more variation at the Reservoir locations than in Rainy Lake, especially at drawdown depths of one to three meters. Mean invertebrate diversity values were lower at the Reservoir locations, and the difference in diversity values between the Reservoir and Rainy Lake locations was greatest at depths of one and two meters. Mean equitability values were lower at Reservoir locations, especially at depths of one and two meters. The range of equitability values was much greater at Reservoir locations because of lower values found there. Invertebrate density at Reservoir locations was significantly higher in the year with the least drawdown during the study.

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INTRODUCTION

Previous studies by others have found that drawdown can greatly reduce invertebrate populations. Grimas (1961) examined Lake Blasjon in northern Sweden after it had been subjected to six meter winter drawdowns for ten years. He found that invertebrate density was reduced 70% in the drawdown zone and 25% elsewhere. He believed the reduction was due to the destruction of macrophytes in the drawdown zone. Others have reported drawdown causing direct mortality by stranding organisms (Hynes 1961, Cowell and Hudson 1968, Benson and Hudson 1975, Kaster and Jacobi 1978). McAfee (1980) studied four small reservoirs in mountain valleys in the Front Range area of Colorado. Two had stable water levels, and two were completely drained each year. Drawdown began in mid to late August and was complete by mid September, and refill began by mid October. On each sampling date, only one dredge sample was taken in the littoral zone, so no conclusive evidence was obtained. However, she made the observation that the littoral benthic invertebrate fauna was sparse in the two drawdown reservoirs and relatively dense in the two nonfluctuating reservoirs. At least one study concluded that drawdown did not affect invertebrate density (Ploskey 1982).

This is the final report of a three year study conducted in Voyageurs National Park to determine the effect of unnatural winter drawdown on benthic invertebrate populations in three Namakan Reservoir lakes: Kabetogama, Namakan, and Sand Point. For more than 70 years, dams at International Falls and Kettle Falls have been operated in such a way that these lakes have greater than normal winter drawdown. In order to determine the effect of this increased winter drawdown on benthic invertebrates, we compared invertebrate populations in the Namakan Reservoir lakes with those in adjacent Rainy Lake which had little winter drawdown. More than 700 invertebrate samples were collected between August 1983 and June 1986.

METHODS

Five study locations were selected. Three were in Namakan Reservoir lakes which experienced unnaturally increased winter drawdowns, and two were in Rainy Lake which had reduced water level fluctuations (Figure 1). The Namakan Reservoir locations were: Moxie in Kabetogama Lake in Irwin Bay near Moxie Island (T69N, R21W, sections 35 and 36); Junction in Namakan Lake in Junction Bay (T69N, R18W, section 32); and Swanson in Sand Point Lake in Swanson Bay (T68N, R17W, section 2). The two Rainy Lake locations initially selected were: Black in Black Bay near Squaw Frank Island (T70N, R22W, section 10); and Inside Passage (Figure 2). It was hoped that Black location would be similar in many physical characteristics to Moxie location and Inside Passage

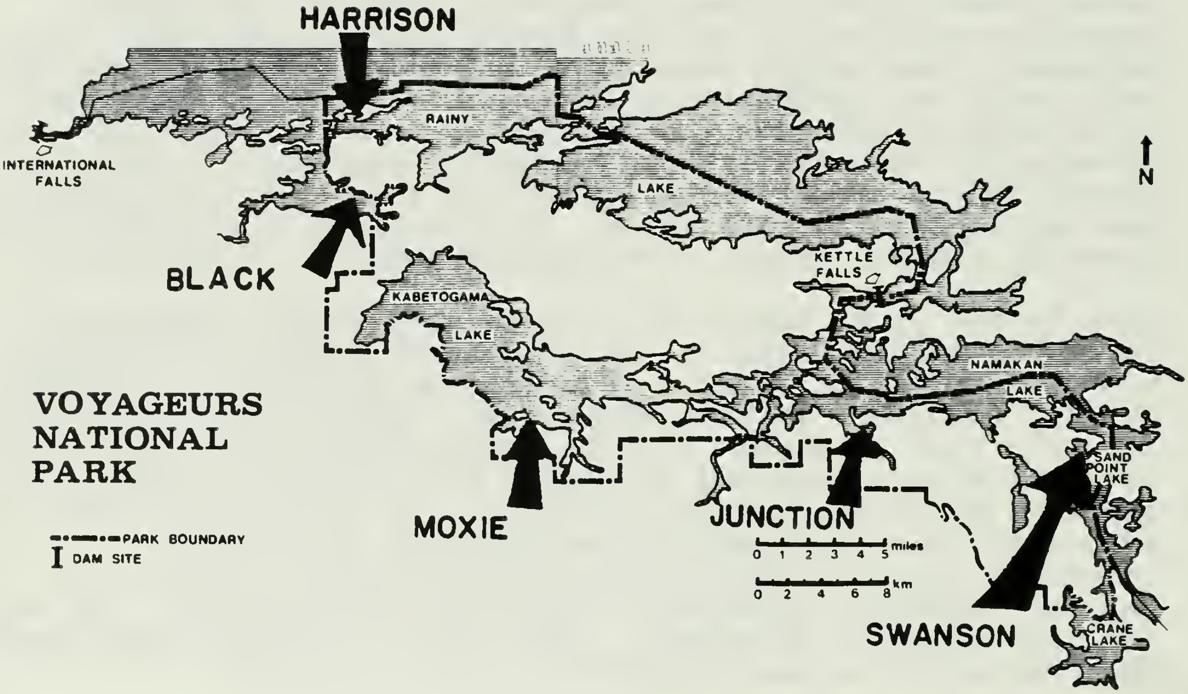

Figure 1. Map showing the locations of the five study areas: Harrison and Black in Rainy Lake; Moxie in Kabetogama Lake; Junction in Namakan Lake; and Swanson in Sand Point Lake.

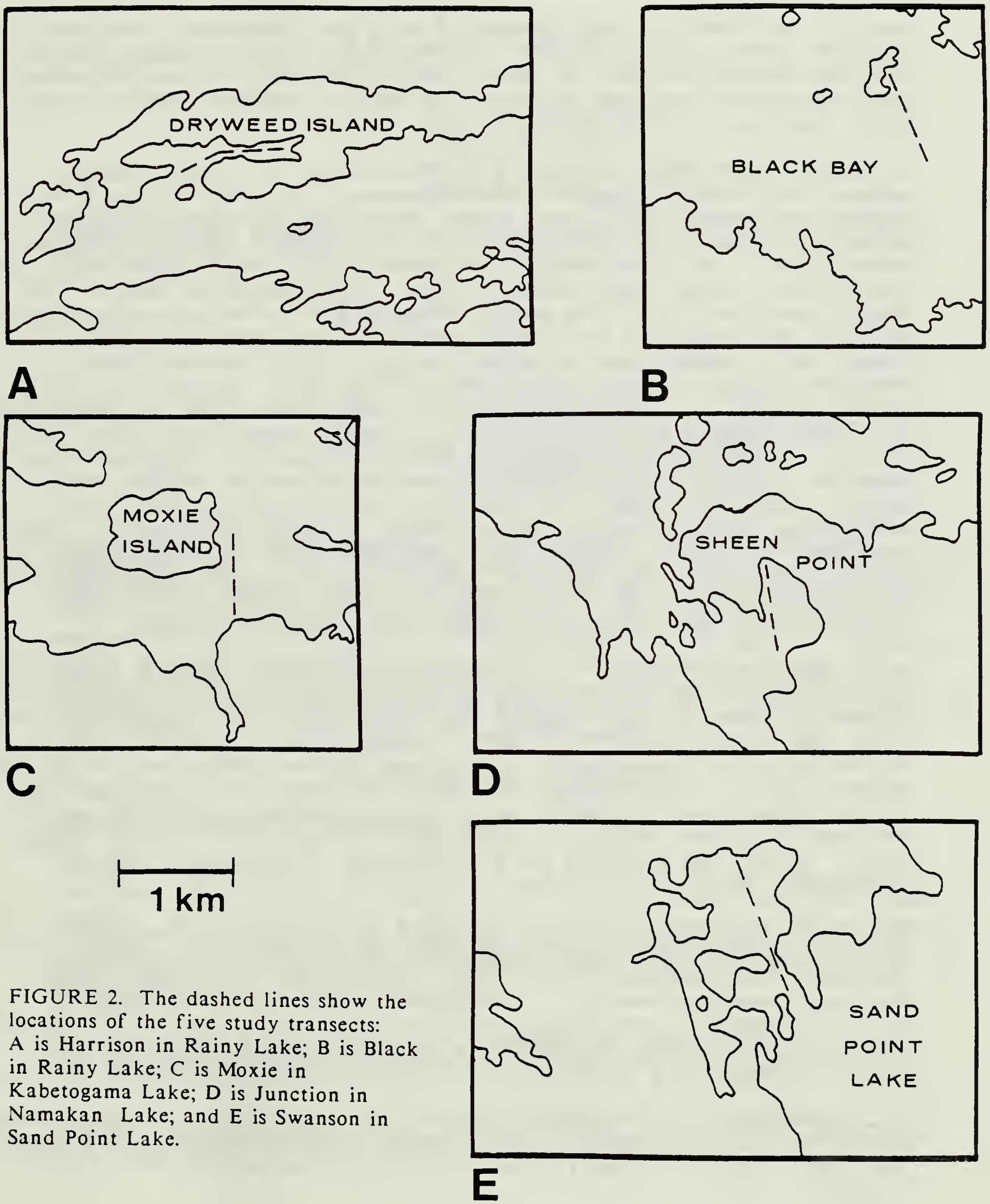

FIGURE 2. The dashed lines show the locations of the five study transects: A is Harrison in Rainy Lake; B is Black in Rainy Lake; C is Moxie in Kabetogama Lake; D is Junction in Namakan Lake; and E is Swanson in Sand Point Lake.

similar to Junction and Swanson locations. However, sediment samples taken in August 1983 showed that Inside Passage had much coarser sediment than the other locations, and it was replaced with Harrison location in Harrison Bay in Dryweed Island (T71N, R22W, section 26) (Figure 2).

An Ekman grab which sampled a surface area of 0.0232 square meters was used to sample invertebrates. At each of the five study locations, triplicate Ekman grab samples were collected along a transect at depths of 1, 2, 3, 4 and 5 meters with two exceptions. In Black Bay, five meter depths were never found and four meter depths were found on only three sampling dates. At Moxie location, the five sampling depths were marked with buoys on July 24, 1984 and all subsequent samples were collected near these buoys regardless of water depth. All transects were sampled within a period of three to five days of the following dates: August 31, 1983 (Harrison not sampled); June 7, 1984; July 16, 1984; August 25, 1984; June 11, 1985; August 26, 1985; and June 3, 1986. The six sampling periods when all transects were sampled (June 1984 to June 1986) are referred to as the six common sampling dates. In addition, Moxie location was also sampled on the following dates: March 1, 1984; October 23, 1984; December 15, 1984; January 14, 1985; February 14, 1985; March 15, 1985; April 12, 1985; May 23, 1985; July 19, 1985; September 20, 1985; October 15, 1985; December 19, 1985; January 17, 1986; February 19, 1986; March 17, 1986; and April 22, 1986.

Each Ekman grab sample of invertebrates was put into a five quart plastic bucket with a label showing location, depth and date. On shore the samples were washed through a #30 U. S. Standard sieve with mesh openings of 0.59 mm to remove fine sediment. The sieved material was placed in cottage cheese containers with 80% ethanol and 1% rose bengal dye which stained live organisms red. In the laboratory, animals were hand picked by examining small amounts of sieved material dispersed in water in a white enamel tray. Later the animals were identified to genus or higher taxonomic level and counted.

Sediment samples for organic content analysis were taken with an Ekman grab at each sample depth on all transects in August 1983 (Harrison not sampled), June 1984, June 1985, and August 1985. Sediment samples were put into plastic bags and refrigerated until subsamples were dried to a constant weight at 105 C, ashed for 1.5 hr at 550 C, cooled in a dessicator and weighed. The ashing process was repeated until weight change was less than 5%.

A Shannon-Wiener diversity index and an equitability value (Krebs 1972) were determined for each sample collected on the six common sampling dates. Diversity was calculated using the following formula:

$$H = -\sum_{i=1}^{S} p_i(\log_2 p_i)$$

where

H = index of diversity

S = number of taxa

p_i = proportion of total sample belonging to $_i$th taxon.

Equitability, evenness of allotment of individuals among taxa, was calculated by the following formula:

$$E = \frac{H}{H_{max}}$$

where

E = equitability

H = observed index of diversity

H_{max} = diversity index under conditions of maximum equitability.

Differences between lakes in total number of invertebrates, total number of taxa, the number of selected taxa and the diversity of each summer sample were analyzed using the Wilcoxon Signed Rank test or the Mann-Whitney U statistic. The relationship of sediment organic content and invertebrate density was examined using the Spearman rank correlation coefficient, as was the relationship between number of taxa and number of individuals at the one and two meter buoys at Moxie location. A probability of less than .05 was accepted as significant.

RESULTS AND DISCUSSION

WATER CHEMISTRY AND PRIMARY PRODUCTIVITY

The pH, alkalinity, conductivity, calcium content, chlorophyll content, and primary productivity of Rainy Lake, and the three Namakan Reservoir lakes were measured by Kepner and Stottlemyer (1988). They found that each of these values was relatively low and similar in Rainy Lake, Namakan Lake, and Sand Point Lake, but much higher in Kabetogama Lake.

For example, in August, when differences were greatest, the chlorophyll-a concentration in an open water area near Moxie location in Kabetogama Lake was more than five times higher than in a similar area near Harrison location in Rainy Lake, and primary productivity (mean carbon assimilation rate) was more than six times higher in Kabetogama Lake.

ORGANIC CONTENT

The percent of organic material found in each sediment sample is given in Appendix E. Wilcoxon signed rank tests showed no significant differences in organic content between the June 1984 and August 1985 samples at Black, Moxie, Junction or Swanson. However, at Harrison the June 1984 samples had significantly less organic matter than the August 1985 samples (p=0.0277). The differences at Harrison between the two dates were not large. For example, the average organic content found in one meter samples in June 1984 was 51% and in August 1985 55.5%.

Each location seemed to have a different pattern of change of organic content with depth (Table 1). The patterns at Black and Swanson were similar in that both had more than 60% organic content at one meter and more than 19% at the other depths. Harrison had very low percentages at three and four meters and Junction had low levels at all depths. Harrison and Black locations in Rainy Lake and Junction and Swanson locations in Namakan Reservoir all had the highest percent of organic matter at one meter depth. But Moxie had low organic content at one meter and increasing levels with greater depth.

Table 1. Mean percent organic content of all sediment samples analyzed. One standard deviation in parenthesis.

	Rainy Lake		Namakan Reservoir		
Depth	Harrison	Black	Moxie	Junction	Swanson
1	56.2(8.14)	63.2(9.96)	10.2(17.99)	17.9(10.07)	66.9(18.30)
2	19.2(8.82)	21.4(5.51)	35.7(23.37)	9.0(5.29)	38.8(15.34)
3	2.5(0.16)	21.1(2.86)	37.5(16.37)	15.0(3.79)	26.4(6.26)
4	4.1(1.37)	21.8(4.29)	53.5(13.45)	7.6(3.56)	28.8(6.44)
5	9.1(5.30)	** (**)	55.6(9.51)	3.2(0.70)	19.3(3.95)

(** no samples.)

Organic content is related, in part, to the physical energy level along the transects. The deeper sampling areas at Harrison and Junction locations were more exposed to waves and wind-driven currents than were the shallower depths. At Moxie location, islands protected the deeper areas but the one meter depth was exposed to northwest winds.

Spearman rank correlation coefficients were determined for mean organic content of sediment samples and mean invertebrate density for each location. Only at Harrison was the correlation statistically significant (p=.01) (Table 2).

Table 2. Spearman rank correlation coefficients between mean sediment organic content and mean invertebrate density.

Location	correlation	N	significance level .05	.01
Harrison	0.736	15	.441	.623
Black	-0.160	11	.535	.729
Moxie	-0.252	20	.377	.534
Junction	0.246	20	.377	.534
Swanson	0.176	20	.377	.534

WATER LEVELS

The monthly mean and range of water levels for Rainy Lake and Namakan Reservoir are shown in Figure 3. The one, two and three meter depths indicated in this figure are based on lake level elevations on July 24, 1984 when buoys were placed at Moxie, not on annual high water levels. Figure 3 indicates that all depths sampled in Rainy Lake were not dewatered while the one and two meter sampling depths in the Namakan Reservoir lakes were dewatered each winter. Drawdown from high water to low water for the three years of this study averaged 1.133 meters (3.72 feet) in Rainy Lake and 2.486 meters (8.16 feet) in Namakan Reservoir (Table 3). During this study, annual low water level occurred in Rainy Lake between March 28 and April 4 and in Namakan Reservoir between March 28 and April 5. Maximum high water in Rainy Lake occurred between July 2 and July 7 and in Namakan Reservoir between June 30 and August 2.

Table 3. Annual drawdown in meters 1983-84 to 1985-86.

Year	Rainy Lake	Namakan Reservoir
83-84	1.064	2.453
84-85	1.069	2.284
85-86	1.266	2.720
Mean	1.133	2.486

Calculating the duration and extent of dewatering from water level data produced underestimations. This was because ice formation removed liquid water and increased the extent and duration of dewatering. For example, in the winter of 1985-86,

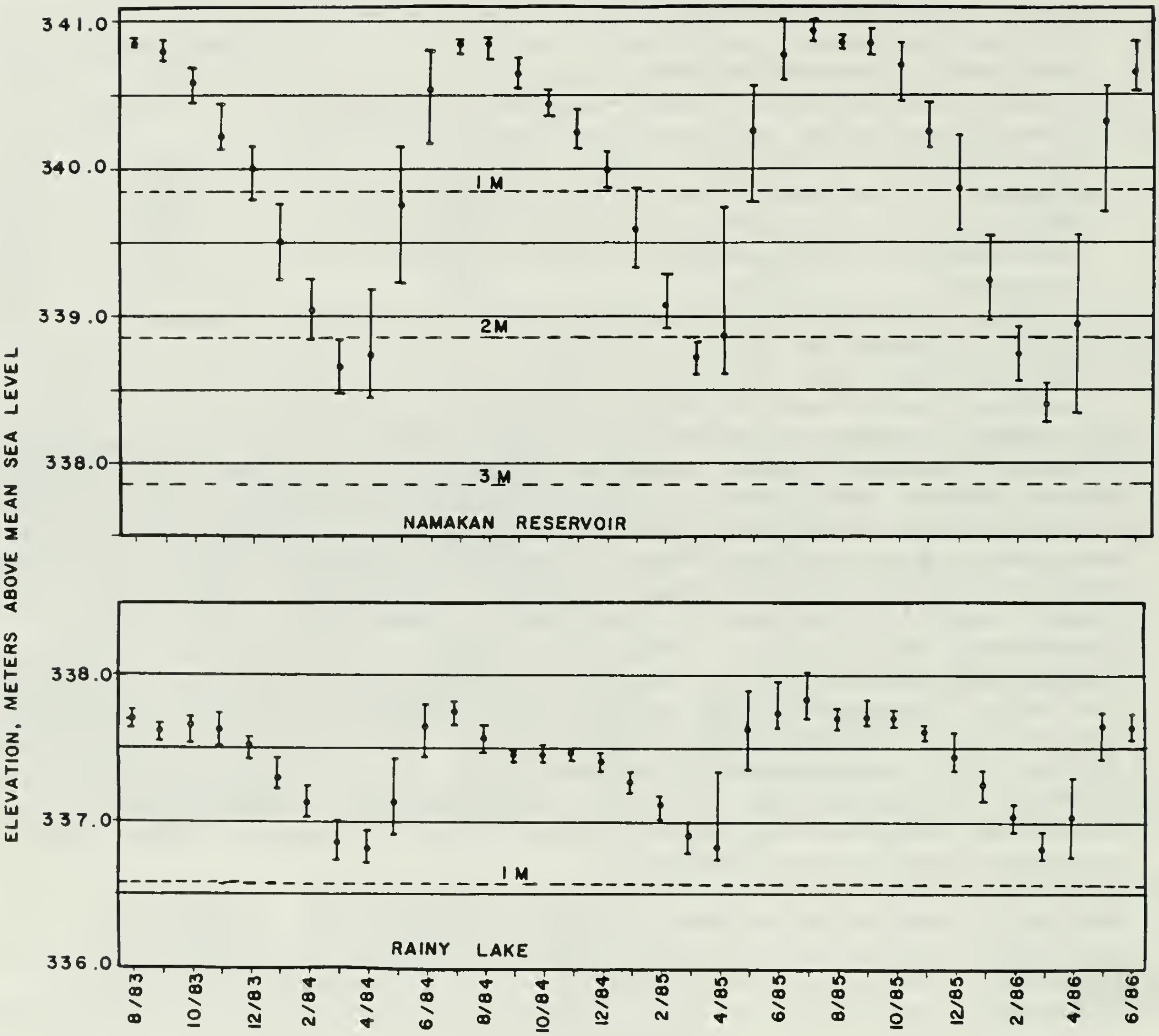

Figure 3. Monthly water level data in meters above mean sea level for August 1983 to June 1986 for Namakan Reservoir and Rainy Lake. The dot indicates the monthly mean, and the bar shows the monthly range. The dashed lines show the one, two and three meter depths in Namakan Reservoir and the one meter depth in Rainy Lake on July 24, 1984.

water level data indicated that the one meter sampling depth in Namakan Reservoir was without water for 111 days beginning on January 3 (Table 4). It was demonstrated that this was an underestimation when samples were collected there on December 19, 1985, 15 days prior to January 3, and there was no water above the sediment. Ice was 0.25 meters thick at that time. Water level data indicated that the 3 meter sampling depth at Moxie location was always below the drawdown zone (Figure 3), but when samples were collected there on March 17, 1986, there was no water above the sediment. The ice was 0.48 meters thick. Water had always covered the sediment at this buoy location on other sampling dates, but March 1986 water levels were lowest of any time during the study. These observations indicate that in late winter when ice thickness was maximum, drawdown in Namakan Reservoir was approximately 0.4 meters greater than water level data indicated. If this was also true in Rainy Lake, the one meter sampling sites in Rainy Lake may have also been dewatered at times.

Table 4. Duration of dewatering at the one and two meter sampling depths in Namakan Reservoir based on water level data.

Year	1 meter depth	2 meter depth
83-84	116 days Jan. 12 - May 9	52 days Feb. 29 - Apr. 20
84-85	119 days Jan. 5 - May 4	50 days Mar. 5 - Apr. 22
85-86	111 days Jan. 3 - Apr. 29	39 days Feb. 28 - Apr. 7
Mean	115.3 days	47.0 days

Table 5 shows the lake elevations in meters above sea level for the various sampling dates. There was little difference in lake levels for the June samples in Rainy Lake. The greatest difference in elevation between the three June sampling dates in Rainy Lake was only 0.046 meters. But the maximum difference in lake levels among the three June dates at Junction location in Namakan Lake was 0.826 meters and at Swanson location in Sand Point Lake it was 0.801. The maximum difference in lake elevation among the three August sampling dates was not great at any of the locations. It was: 0.131 meters at Harrison; 0.101 at Black; 0.076 at Junction; and 0.070 at Swanson.

Table 5. Lake levels (meters above mean sea level) at the times of summer sampling. Harrison was not sampled in August 1983.

	Rainy Lake		Namakan Reservoir		
Date	Harrison	Black	Moxie	Junction	Swanson
8/83	NS	337.670	340.882	340.885	340.879
6/84	337.700	337.700	340.245	340.251	340.286
7/84	337.770	337.770	340.827	340.833	340.834
8/84	337.569	337.569	340.809	340.809	340.809
6/85	337.718	337.718	340.678	340.690	340.665
8/85	337.700	337.661	340.840	340.840	340.830
6/86	337.672	337.672	339.945	339.864	339.864
mean	337.688	337.680	340.604	340.596	340.595

INVERTEBRATE DENSITY

The 732 Ekman grab samples contained approximately 80,000 animals. The complete data for each sample are given in Appendix A, and the mean number of invertebrates per square meter found during the summer sampling is shown in Table 6. Density ranged from 370 at three meters at Harrison in July 1984 to 36,567 at one meter at Moxie in August 1985.

The average density of invertebrates showed a pattern similar to that of productivity and water chemistry, being lower and roughly equal in Rainy, Namakan, and Sand Point lakes, but 2.7 times greater at Moxie location in Kabetogama Lake (Table 7). Wilcoxon Signed Rank tests showed that invertebrate density at Moxie location at one, three, four and five meters was significantly greater than at all other locations. At two meters, density at Moxie was significantly greater than all other locations except Swanson. Density at Harrison was not significantly different from that at Junction and Swanson at one, two, and four meters. At three and five meters Swanson had significantly greater density than Harrison.

The density at Moxie was not uniformly higher throughout the year. The mean density at one meter at Moxie for August 1984 and August 1985 averaged 3.96 times greater than at Harrison and Black, while the average mean density at Moxie for June 1984, June 1985 and June 1986 was only 1.20 times that at Harrison and Black. There were six occasions when Rainy Lake locations had higher densities than Moxie. These were: June 1984 at three meters when density at Black was greater; August 1984 at two meters when density at both Black and Harrison was greater; June 1986 at two meters when density at Harrison was greater; August

1983 at one meter when density at Black was greater; and June 1985 and June 1986 at one meter when density at Harrison was greater. However, below the drawdown zone at sample depths of four and five meters, densities were greater at Moxie on all sampling dates. Because these unexpected, lower densities at Moxie location occurred only at sampling depths in the drawdown zone and most often in June following low water periods, it appears likely that drawdown reduced, at least temporarily, the invertebrate density at Moxie location.

Table 6. Average number of invertebrates per square meter for the seven summer sampling dates. NS indicates no samples.

ONE METER	8/83	6/84	7/84	8/84	6/85	8/85	6/86
Harrison	NS	1895	4349	1895	10850	9787	6187
Black	7836	1003	5279	10389	2885	6127	2510
Moxie	7505	2984	12732	21601	8181	36567	4077
Junction	2868	904	7965	1679	7134	14251	6273
Swanson	1305	5283	1150	1537	7866	6945	5309
TWO METERS	8/83	6/84	7/84	8/84	6/85	8/85	6/86
Harrison	NS	2786	2282	4951	6859	4077	8181
Black	5925	1666	1175	2928	2110	1279	1636
Moxie	5912	5025	4034	2338	8697	29450	2872
Junction	947	616	2467	5511	8452	7177	1839
Swanson	6773	1219	2786	1421	11970	4866	1735
THREE METERS	8/83	6/84	7/84	8/84	6/85	8/85	6/86
Harrison	NS	431	370	1864	1451	1464	2614
Black	4164	3083	1322	4508	2355	5869	1795
Moxie	5899	2958	3358	7479	5283	8150	2381
Junction	1292	547	1839	517	775	1968	745
Swanson	1292	689	1580	3328	4164	6299	659
FOUR METERS	8/83	6/84	7/84	8/84	6/85	8/85	6/86
Harrison	NS	676	891	1119	1494	1089	1089
Black	4390	NS	NS	NS	2596	3574	NS
Moxie	4120	3746	2368	3401	7449	9589	2441
Junction	1636	1033	418	590	2166	2657	745
Swanson	904	1206	345	719	2131	1279	418
FIVE METERS	8/83	6/84	7/84	8/84	6/85	8/85	6/86
Harrison	NS	1666	400	702	861	590	633
Black	NS	NS	NS	NS	NS	NS	NS
Moxie	3746	1133	2054	3702	8051	7320	3961
Junction	474	1150	517	99	1507	1593	1391
Swanson	1020	1722	831	874	2570	1666	616

Table 7. The mean invertebrate density per square meter of all samples collected on the six common sampling dates, the standard deviation of the mean (S.D.) and the Coefficent of Variation (C V). NS indicates no samples.

	Depth, m				
Station	1	2	3	4	5
Harrison					
mean	5834	4831	1421	1060	811
S.D.	4152	2502	871	431	961
C V	.712	.518	.613	.407	1.185
Black					
mean	4697	1799	3155	3086	NS
S.D.	3872	680	1999	655	NS
C V	.824	.378	.634	.212	NS
Moxie					
mean	14359	8809	5089	4831	4534
S.D.	12594	9907	2735	3470	2731
C V	.877	1.125	.537	.718	.602
Junction					
mean	6368	4370	1064	1275	1043
S.D.	4990	3416	789	1004	742
C V	.784	.782	.742	.788	.711
Swanson					
mean	4693	4002	2787	947	1335
S.D.	3845	4006	2266	691	773
C V	.819	1.001	.813	.730	.579

Coefficients of variation (C V) at one meter were similar at all stations and ranged from .712 at Harrison to .877 at Moxie. At two meters, the C V for the Rainy Lake locations were much lower (average .448) than those from the Namakan Reservoir locations (average .969). At three meters, the average C V at Rainy Lake locations was .624 and at Namakan Reservoir locations .697, and at four meters they were .310 and .745, respectively. At depths of two, three and four meters, there was only one instance (Moxie three meters) when a Namakan Reservoir location had a C V less than either of the Rainy Lake locations. This indicates that at one meter depth Rainy Lake and Namakan Reservoir locations had similar high levels of variation, presumably because one meter depths in all lakes were affected by drawdown. At depths of two, three and four meters, variation was generally greater at the Namakan Reservoir locations, presumably as a result of the increased drawdown in the Reservoir.

If drawdown caused reduced invertebrate density in the spring and density increased later in the year, variation in density between sampling dates should be greatest in those lakes and at those depths most affected by drawdown. That is exactly what was observed. The ratio between lowest and highest density for each depth was greatest at one and two meters in the Namakan Reservoir lakes followed by the one meter depth in Rainy Lake (Table 8). The three to five meter depths in Namakan Reservoir lakes and the two to five meter depths in Rainy Lake had much lower ratios.

Table 8. Ratio of lowest to highest density at each depth for samples collected on the six common sampling dates.

	Rainy Lake			Namakan Reservoir			
Depth	Harrison	Black	Mean	Moxie	Junction	Swanson	Mean
1	5.8	10.5	8.15	7.3	15.8	8.4	10.5
2	3.6	2.5	3.05	12.2	14.3	9.9	12.1
3	6.8	4.4	5.60	3.4	3.5	9.7	5.5
4	2.2	*	2.20	4.0	5.0	6.3	5.1
5	4.3	**	4.30	4.4	14.8	4.2	7.8

(* two sampling dates; ** no samples.)

Densities of the June one meter samples followed an identical pattern at all locations. They were highest in June 1985 followed by June 1986 and June 1984. At Black, Moxie, and Junction, June 1984 samples had the lowest densities of all summer samples. At all depths at the three Namakan Reservoir locations, the mean number of invertebrates in the June 1985 samples was greater than those of the June 1984 and 1986 samples. Wilcoxon Signed Rank tests showed that the number of invertebrates in the June 1985 samples from the three Namakan Reservoir locations was significantly greater than those in the June 1984 samples at one, two, three, and four meters (p= .0126, .0089, .0175 and .0459, respectively), but not at five meters (p=.2362). The June 1985 Namakan Reservoir samples also contained significantly more invertebrates than the June 1986 samples at one, two, three and four meters (p=.0140, .0089, .0241, and .0140, respectively), but not at five meters (p=.9528). At Namakan Reservoir locations, there were no significant differences between the number of invertebrates collected in June 1984 and June 1986 at one, two and three meters (p= .3628, .4772, .9442, respectively), but at four meters the June 1984 samples contained significantly more (p=.0327), and at five meters the June 1986 samples contained significantly more (p=.0379).

In Rainy Lake the mean number of invertebrates in the June 1984 samples at five meters at Harrison and three meters at Black was greater than those in June 1985 and 1986. At one and two meters at Harrison, June 1986 samples contained more invertebrates than those in June 1985 and 1984. The June 1985 Rainy Lake samples contained significantly more invertebrates than the June 1984 samples at one and two meters (p=.0357 for both). There was no significant difference at three and five meters (p=1.000 and .7893, respectively), and at four meters there were too few untied cases to perform the Wilcoxon signed rank test. There were no significant differences between the number of invertebrates in the Rainy Lake June 1985 and 1986 samples at one, two, three, four or five meters (p=.0589, 1.000, .5346, .7893, and .1815, respectively). There were also no significant differences in numbers between the June 1984 and June 1986 samples at two, three, four or five meters (p=.1422, 1.000, .4224 and .7893, respectively), but at one meter, 1986 samples contained significantly more (p=.0357).

Comparing the August samples collected in 1983, 1984 and 1985 in Namakan Reservoir showed that the 1985 samples contained sigificantly more invertebrates than the 1983 samples at all depths studied: one, two, three, four and five meters (p=.0089, .0437, .0206, .0337 and .0089, respectively). The 1985 samples also contained significantly more invertebrates than the 1984 samples at one, two, four and five meters (p=.0089, .0089, .0126 and .0089, respectively) but not at three meters (p=.0754). There were no significant differences between the number of invertebrates collected in 1983 and 1984 at one, two, three and five meters (p=.2864, .4772, .6250 and 1.0000, respectively), but at four meters the 1983 samples contained significantly more (p=.0281).

On the other hand, the Rainy Lake August samples showed no significant differences at any depth between any of the three years.

What can account for the fact that almost all the June and August 1985 samples from Namakan Reservoir lakes had densities that were significantly higher than June and August samples of the other years studied, while in Rainy Lake there were no significant differences between August samples and only a few between June samples? Since Rainy Lake and Namakan Reservoir lakes are located almost immediately adjacent to one another, it seems unlikely that weather or climate-related factors could have been responsible for this difference. However, between-year differences in drawdown regimes may explain these results. Table 3 shows that in Namakan Reservoir the level of drawdown was considerably less in 1985 (low water 338.607 meters above mean sea level (mmsl)) than in 1984 (338.449 mmsl) and 1986 (338.296 mmsl), and the annual low water occurred seven days earlier in 1985 and 1986 (both March 28) than in 1984 (April 5). While in Rainy Lake there was only 3.5 cm difference in low water elevation for these three years, 336.730 mmsl in 1984 and 336.765 mmsl in 1986, and annual low water occurred earliest in 1986 (March 28), followed by 1985 (April 11) and 1984 (May 4). An early and shallower drawdown in 1985 in Namakan Reservoir may have resulted in the greater densities observed there in June and August 1985.

INVERTEBRATE TAXA

The two Rainy Lake locations were each represented by fewer samples than any of the Namakan locations because at Black location four meter samples were not obtained on four of the seven summer sampling periods and five meter depths were never found there, while Harrison was not sampled in August 1983. As a result, a total of 157 samples were collected from the two Rainy Lake locations and a total of 313 summer samples from the three locations in Namakan Reservoir. The 88 samples collected from Harrison location contained a total of 30 taxa. The 69 samples from Black location contained 18, all of which were also found at Harrison. Of the 30 taxa collected from Rainy Lake, 27 were also present in Namakan Reservoir samples. The three missing taxa were the mayfly Baetisca, a Platyhelminthes flatworm and the isopod Asellus. Baetisca and the flatworm were each represented by a single individual collected in June 1986 at Harrison location, but a total of 524 Asellus were present in 13 samples from Harrison and 10 samples from Black location. At Harrison, Asellus was abundant in all samples collected at one meter June 1985, August 1985, June 1986 and in one sample collected in August 1984. At Black location, this genus was abundant in all samples collected at one meter August 1983, August 1984, August 1985 and June 1986. Asellus was also present in very low numbers in a few samples from depths greater than 1 meter at the Rainy Lake locations. A possible explanation for the absence of Asellus from Namakan Reservoir is discussed later.

The 104 summer samples from Moxie location in Kabetogama Lake contained a total of 28 taxa. The 105 summer samples from Junction location in Namakan Lake contained 26 taxa and the 104 summer samples from Swanson location in Sand Point Lake 27 taxa. Together these three Namakan Reservoir locations produced a total of 33 taxa, six of which were not collected at the Rainy Lake locations. These six taxa were each represented by a total of only one to four individuals which were present in only one to three samples. Agraylea, Banksiola and Deronectes were found only at Moxie location. Didymops and Hydroporus were found at Junction and Swanson locations, and Paraponyx at Moxie and Junction locations. These six taxa may also occur in low numbers in Rainy Lake, and more extensive sampling there might have included them. It is not unexpected that more taxa would be found in the more numerous Namakan Reservoir samples. What is surprising is that 313 samples from the three Namakan Reservoir lakes contained a total of only three more taxa than the 157 samples from two locations in Rainy Lake. This suggests that taxonomic diversity was lower in the Namakan Reservoir lakes than in Rainy Lake.

The mean number of taxa per sample is given in Table 9. At depths of one and two meters, Harrison location had the highest number of taxa per sample. These are the sampling depths in Namakan Reservoir regularly affected by winter drawdown. At three, four and five meter depths, Moxie location had the highest number of taxa. Wilcoxon Signed Rank tests showed that the number of taxa in samples from one meter at Harrison was significantly greater than at all other locations except Junction. The other locations were not significantly different from each other. At two meters, the number of taxa in samples from Harrison was significantly greater than at Black and Swanson, and the number at Junction was significantly greater than at Black. At three, four and five meters, the number of taxa in samples from Moxie was significantly greater than at all other locations. The other locations were, with few exceptions, not significantly different from each other. The mean number of taxa per sample varied with time. At one and two meters it was highest on average in August 1985 and lowest in June 1984. The variation between sampling dates was greater at Namakan Reservoir locations than at Rainy Lake locations. At one meter depth, the average difference between the highest and lowest mean number of taxa for Namakan Reservoir locations was 9.97 and for Rainy Lake locations it was 6.05. At two meters, the average difference was 7.6 for Namakan Reservoir locations and 5.7 for Rainy Lake locations. At depths of three, four and five meters, at Namakan Reservoir locations the average difference ranged from 5.2 to 6.1 and at Rainy Lake locations from 3.3 to 4.7. The greater variation in numbers of taxa between sampling dates at Namakan Reservoir locations suggests there was greater instability in the invertebrate community in Namakan Reservoir lakes. The fact that Moxie location had the highest mean number of taxa per sample at three, four and five meters, but not at one and two meters also suggests that the unnatural winter drawdown in Namakan Reservoir resulted in a reduction in the number of taxa in the drawdown zone.

Table 9. Mean number of invertebrate taxa for the three Ekman grabs taken at each depth on the seven summer sampling periods NS indicates no samples. Standard deviation in parentheses.

	Depth, m				
Date Location	1	2	3	4	5
August 1983					
Harrison	NS	NS	NS	NS	NS
Black	8.3(2.5)	7.3(0.6)	4.3(0.6)	4.7(1.2)	NS
Moxie	7.3(1.5)	5.0(1.7)	7.0(1.4)	7.0(0.0)	7.7(2.1)
Junction	5.3(0.6)	6.0(2.7)	5.7(0.6)	6.3(0.6)	4.3(0.6)
Swanson	7.7(2.3)	7.3(3.2)	6.0(0.0)	3.7(1.5)	4.0(1.0)
June 1984					
Harrison	9.0(1.7)	7.0(3.0)	3.7(0.7)	3.7(0.6)	4.3(3.2)
Black	5.3(0.6)	6.7(0.6)	5.3(1.5)	NS	NS
Moxie	4.0(1.0)	6.3(0.6)	6.7(0.6)	6.3(2.1)	5.0(1.0)
Junction	2.7(0.6)	4.3(0.6)	3.3(1.2)	3.3(1.5)	4.7(1.2)
Swanson	5.3(1.2)	3.3(1.5)	3.3(2.5)	4.3(0.6)	4.3(0.6)
July 1984					
Harrison	7.7(1.5)	8.0(3.0)	3.0(1.0)	5.0(1.0)	3.7(0.6)
Black	7.0(1.7)	3.3(1.5)	5.7(1.2)	NS	NS
Moxie	6.7(0.6)	6.3(1.5)	6.7(0.6)	4.7(2.1)	4.0(1.0)
Junction	6.0(1.0)	4.7(2.1)	4.3(1.5)	3.0(1.0)	1.7(1.5)
Swanson	3.7(1.2)	5.0(1.0)	5.0(1.7)	3.0(2.0)	4.3(0.6)
August 1984					
Harrison	7.3(4.5)	6.5(0.7)	7.7(2.1)	3.7(1.5)	4.0(0.0)
Black	9.3(2.1)	6.7(1.5)	4.7(0.6)	NS	NS
Moxie	11.7(0.6)	7.0(1.7)	9.7(2.1)	5.7(1.2)	6.3(1.2)
Junction	8.3(3.2)	10.7(1.5)	6.0(1.0)	5.0(3.6)	1.5(2.1)
Swanson	8.0(2.7)	5.7(1.2)	8.0(1.7)	5.0(1.7)	4.7(1.2)
June 1985					
Harrison	13.3(1.5)	10.3(1.5)	6.3(0.6)	6.3(1.5)	7.0(1.0)
Black	6.0(1.0)	7.3(0.6)	8.3(2.3)	6.3(1.2)	NS
Moxie	9.7(0.6)	9.7(1.5)	10.0(1.0)	10.7(0.6)	9.3(0.6)
Junction	12.0(2.0)	10.0(1.7)	5.7(1.5)	7.3(1.2)	6.7(1.2)
Swanson	11.3(1.5)	11.0(1.0)	8.3(1.5)	7.0(0.0)	8.3(0.6)
August 1985					
Harrison	14.7(0.6)	12.7(2.5)	8.3(0.6)	7.0(2.7)	6.0(2.0)
Black	9.7(0.6)	6.3(2.1)	8.0(1.0)	6.7(0.6)	NS
Moxie	12.7(1.5)	12.7(0.6)	10.0(3.0)	10.0(1.7)	8.0(1.00
Junction	13.0(1.7)	12.7(0.6)	7.0(2.0)	10.3(2.1)	8.0(0.0)
Swanson	14.3(0.6)	10.0(1.7)	8.7(2.1)	8.0(0.0)	8.0(1.0)
June 1986					
Harrison	12.0(1.0)	12.3(1.5)	9.0(1.7)	6.3(1.5)	4.7(1.2)
Black	9.0(0.6)	8.0(1.7)	8.0(0.0)	NS	NS
Moxie	7.3(0.6)	8.7(2.1)	7.7(1.2)	7.7(1.5)	9.3(2.3)
Junction	13.3(0.6)	8.3(1.5)	6.0(2.0)	6.0(1.0)	5.0(3.0)
Swanson	7.0(1.7)	6.0(1.0)	5.0(2.7)	3.3(0.6)	3.7(1.5)

If the invertebrate communities in Namakan Reservoir were little affected by winter drawdown, populations there should have had changes similar to those in Rainy Lake. The change in the maximum number of taxa in a sample between June and August 1984 and June and August 1985 is shown in Table 10. At depths of one, two and three meters, there was generally a greater increase in numbers of taxa at the Namakan Reservoir locations than at the Rainy Lake locations. At these depths, the Rainy Lake locations showed four instances of decrease in number of taxa and the Namakan Reservoir locations showed none. At four and five meters depth, the change in number of taxa at the Namakan Reservoir locations was much less than at shallower depths. These data suggest that drawdown in Namakan Reservoir caused a reduction in the number of taxa in June compared to August at depths of one, two and three meters.

Table 10. The change in the maximum number of taxa in a sample between June and August 1984 and June and August 1985. The last two lines give the mean of the Rainy Lake and Namakan Reservoir locations. NS indicates no samples.

	Depth, m									
	1		2		3		4		5	
Year	84	85	84	85	84	85	84	85	84	85
Harrison	-1	0	-3	3	6	2	1	2	4	0
Black	4	3	2	0	-2	-2	NS	0	NS	NS
Moxie	7	4	2	2	5	2	-1	0	1	-1
Junction	9	0	7	2	3	2	3	4	-2	0
Swanson	4	2	2	0	4	1	1	1	1	0
Mean										
Rainy L.	1.5	1.5	-0.5	1.5	2.0	0.0	1.0	1.0	4.0	0.0
Namakan R.	6.7	2.0	3.7	1.3	4.0	1.7	1.0	1.7	0.0	-0.3

On all six dates when Harrison location was sampled, the mean number of taxa collected at one and two meters was nearly always considerably greater than that at three, four or five meters. The one meter depth averaged 3.8 more taxa than the three meter depth, and the two meter depth averaged 3.2 more taxa. On the same dates at Moxie location, this pattern was seen only in August 1984 and August 1985. Examining the pattern of number of taxa found at the five sample depths for all twenty-two dates when Moxie location was sampled showed that the one and two meter buoy locations had considerably more taxa than other depths only in August 1984 and August 1985. In October 1984, the one meter depth averaged only 0.5 more taxa than the three meter depth which was second in mean number of taxa. The one meter buoy location was not sampled in December 1984, January, February, March or April 1985 because it was dewatered. When it was sampled in May 1985, the mean number of taxa there was lower than all other depths. In June and July 1985, the number of taxa at one meter was next to lowest; only at the five meter buoy were fewer taxa found. But in August 1985, the one and two meter depths at Moxie had mean numbers of taxa 3.0 and 3.7, respectively, higher than any of the other depths. In September and October 1985, the one meter buoy ranked third and first, respectively, in number of taxa. In December 1985 when winter dewatering first reached the one meter buoy location, it had fewer taxa than any other buoy location, less than half the number of taxa of the next to lowest. The one meter buoy location was not sampled in January, February, March and April 1986 because it was without water. When the one meter buoy location was next sampled in June 1986, it had fewer taxa than any other depth. The number of taxa at the two meter buoy followed a similar pattern, but the decline in taxa occurred two to three months later in the winter and the recovery one month earlier in the spring, corresponding with water level changes at that depth. These data support the view that dewatering reduced the number of taxa in the drawdown zone in Namakan Reservoir and that the normal taxa-depth pattern did not become reestablished until August.

Like the number of taxa, the number of invertebrates collected at the one meter buoy location at Moxie was high in August 1984 and August 1985. In August 1984, density was 4.02 times higher than in June 1984, while the August 1985 density was 4.47 times greater than in June 1985. At the two meter buoy in 1984, the peak density occurred in October and was 1.55 times greater than June density. In 1985 at the two meter buoy, the peak density occurred in August and was 3.39 times greater than in June. At the one and two meter buoys at Moxie location, the number of invertebrates in samples showed a significant positive correlation with the number of taxa in samples. Using only samples containing invertebrates, the Spearman rank correlation coefficient between total number of invertebrates and number of taxa at the one meter buoy location was 0.6347 for 37 samples, and at the two meter buoy location, it was 0.6468 for 60 samples. This indicates that the density of invertebrates at Moxie location showed a similar pattern to that of the number of taxa, an abrupt drop with dewatering and recovery by August or October.

The percent occurrence in samples of the 20 most frequently collected taxa is given in Table 11. At one and two meter depths, there were four taxa which were found much less frequently at Namakan Reservoir locations than at Rainy Lake locations. These were Hexagenia, Chaoborus, Asellus, and Sialis. These taxa were also collected less frequently in Namakan Reservoir than in Rainy Lake at three, four and five meter depths, but the difference was not as great. *Asellus*, *Hexagenia* and *Sialis* are discussed separately later in this report. *Chaoborus* larvae are predators which feed primarily on microcrustacea (Merritt and Cummins 1984). Grimas (1961) found a reduction in microcrustacea in regulated Lake Blasjon. If increased drawdown in Namakan Reservoir had reduced the populations of any of the key prey species of *Chaoborus*, this could account for their reduced frequency in Namakan Reservoir. Differential rates of fish predation on *Chaoborus* could also cause this difference. At one and two meters there were two taxa which were collected much more frequently in Namakan Reservoir lakes than in Rainy Lake. They were Amphipoda and *Oecetis*. Amphipoda are discussed later. Larvae of the caddisfly *Oecetis* are predators on small invertebrates such as chironomids (Wiggins 1977) which were more numerous in Namakan Reservoir. This could explain the greater frequency of *Oecetis* in Namakan Reservoir if they were prey limited and chironomids were their preferred prey.

At three, four and five meters depths, there were two additional taxa which showed marked differences in frequency of occurrence between the two water bodies. *Caenis* was collected more frequently and Nematoda less frequently in Namakan Reservoir than in Rainy Lake. Nymphs of the small mayfly *Caenis* inhabit quiet water often in the vicinity of plants and plant debris (Edmunds et al. 1976). This sort of habitat was not present at Harrison location at depths of 3, 4 and 5 meters where the percent organic matter ranged from only 2.4 to 8.1. This may account for their reduced frequency there. Nematodes thrive in a wide variety of habitats (Pennak 1978). It is not clear why they were more frequently collected in Rainy Lake.

Table 11. Percent occurrence in samples of the 20 most frequently collected taxa. Data have been combined into two depth categories to group samples according to the intensity of drawdown influence in Namakan Reservoir.

Taxa	1 and 2 meters Rainy	 Namakan Res.	3, 4 and 5 meters Rainy	 Namakan Res.
Chironomidae	100	100	98	94
Ceratopogonidae	78	64	39	53
Oligochaeta	70	70	58	59
Hexagenia	65	23	88	68
Sphaeriidae	60	74	45	60
Gastropoda	54	59	12	14
Amphipoda	52	74	6	27
Chaoborus	52	19	85	67
Caenis	50	59	12	35
Nematoda	32	47	48	17
Asellus	31	0	3	0
Hirudinea	31	48	9	18
Sialis	28	4	46	35
Hydracarina	18	28	29	19
Oecetis	14	40	3	8
Porifera	13	12	1	0
Mystacides	10	15	1	1
Phylocentropus	9	6	1	11
Polycentropus	9	12	0	2
Chrysops	9	7	0	0

DIVERSITY

The mean diversity for all June, July and August samples is shown in Table 12. At Harrison and Black locations in Rainy Lake, diversity was highest at one meter. In Namakan Reservoir lakes, diversity was highest at four meters at Moxie, three meters at Junction and five meters at Swanson. At Harrison in Rainy Lake, diversity declined with depth and was lowest at five meters. In Namakan Reservoir, diversity was lowest at one meter at Moxie, two meters at Swanson and five meters at Junction location. Wilcoxon Signed Rank tests showed that at one meter, diversity at Harrison was significantly greater than at the three Namakan Reservoir locations and that Black location had significantly higher diversitiy than Moxie and Junction. At two meters, diversity at Harrison was significantly greater than at all Namakan Reservoir locations, and Black location diversity was significantly higher than at Swanson. At three meters there were no significant differences between the five locations. At four meters the only significant difference was that diversity at Swanson was lower than at all other locations. At five meters there were no significant differences in diversity between the locations sampled. The difference in average diversity between Rainy Lake and Namakan Reservoir was large in the drawdown zone, but very small at four and five meters (Table 12). This suggests that diversity was reduced in the drawdown zone in Namakan Reservoir lakes.

Table 12. Mean diversity of all June, July and August samples at each location, the mean of Rainy Lake and Namakan Reservoir locations and the difference between the means.

	Depth, m				
Location	1	2	3	4	5
Rainy Lake					
Harrison	2.245	2.174	1.923	1.873	1.807
Black	2.031	1.774	1.911	1.984	NS
mean	2.155	1.980	1.999	1.852	1.807
Namakan Res.					
Moxie	1.516	1.646	1.846	1.868	1.793
Junction	1.709	1.885	1.915	1.879	1.556
Swanson	1.716	1.323	1.730	1.405	1.736
mean	1.672	1.690	1.864	1.836	1.789
Difference in means	0.483	0.290	0.135	0.016	0.018

EQUITABILITY

Equitability is said to be a very sensitive measure of environmental perturbation with a variety of stresses causing equitability values to decrease (Weber 1973). Equitability was generally higher at all sample depths at Rainy Lake locations than at Namakan Reservoir locations (Table 13). The average difference was greatest at one and two meters, .12 and .10, respectively, but only .05 to .07 at three to five meters.

The range of equitability values was greater for the Namakan Reservoir samples than for the Rainy Lake samples, especially in the drawdown zone (Table 13). The average range for Reservoir samples at one meter was 0.46 and at two meters 0.36, while the average for those depths in Rainy Lake was .22 and .15. The lowest average range for Namakan Reservoir samples was 0.20 at five meters. This suggests that drawdown was the stress causing the reduction in equitability.

Table 13. Mean equitability and range of equitability values for samples collected on the six common sampling dates.

Location	Depth, m 1	2	3	4	5
Rainy Lake					
Harrison					
mean	.69	.69	.75	.81	.82
range	.62 -.73	.62 -.74	.68 -.87	.67 -.91	.75 -.91
Black					
mean	.71	.71	.77	*	**
range	.52 -.84	.57 -.84	.72 -.83	*	**
Namakan Res.					
Moxie					
mean	.55	.61	.66	.69	.67
range	.37 -.79	.35 -.70	.57 -.79	.60 -.84	.50 -.83
Junction					
mean	.60	.64	.83	.80	.83
range	.36 -.82	.57 -.76	.60 -.94	.61 -.94	.74 -.83
Swanson					
mean	.58	.56	.63	.72	.75
range	.27 -.77	.32 -.85	.56 -.72	.54 -.89	.66 -.85

(* = two sampling dates; ** = no samples)

STRANDING OF ORGANISMS

The stranding of organisms was observed frequently in winter samples. The first winter samples were collected at Moxie location on March 1, 1984 before buoys were installed. Holes were cut through the ice at distances from shore of 46, 91, 137, 187, 229, 274, 457, 518, and 610 meters. The 46, 91, and 137 meter holes were without water. The sediment in the 46 meter hole was frozen and no animals were found in sediment dug from it. A sample of unfrozen sediment from the 91 meter hole contained chironomids, fingernail clams, Caenis, nematodes, snails and leeches with a total density of 2,064 per square meter. At the 137 meter hole there was a puzzling layer of frozen sediment beneath an unfrozen surface layer. A sample of the unfrozen surface layer contained the taxa listed above except nematodes, plus amphipods, ceratopogonids, Hexagenia, Oecetis, oligochaetes, and Sialis with a total density of 23,392 per square meter. This was one of the highest densities observed during the study and suggests that animals had concentrated there before becoming stranded. The next highest density found in the March 1, 1984 samples was 12,427 organisms at the 610 meter hole where water depth was 1.2 meters (Appendix C).

At the two meter buoy on February 16, 1986 the sediment was dewatered and frozen to a depth of four centimeters. The frozen sediment was chopped away and three samples of the underlying unfrozen material were collected. These samples contained 2 chironomids, 2 amphipods, 1 oligochaete, and 1 ceratopogonid with a total mean density of 86 per square meter. At the one meter buoy on December 19, 1985 the sediment was dewatered but unfrozen. Three samples of sediment contained 7 taxa with a mean total density of 473 per square meter. Sediment at the three meter buoy was found dewatered only on March 17, 1986. Three samples collected then contained 10 taxa with a mean total density of 4,515 per square meter.

There was much evidence that stranding of invertebrates resulted in the death of many of them. For example, in samples of dewatered sediment collected at the two meter buoy March 15, 1985, up to 70% of the Hexagenia and 18% of the amphipods were dead (Table 14). One month later, no live Hexagenia or amphipods were found at this buoy location.

Table 14. Number per square meter of live and dead amphipods and Hexagenia, and percent dead, in samples of dewatered sediment collected at the two meter buoy at Moxie location March 15, 1985.

Sample	Amphipods			Hexagenia		
	live	dead	% dead	live	dead	% dead
A	16,494	2,021	11	602	688	53
B	3,225	688	18	129	86	40
C	4,214	731	15	129	301	70

AMPHIPODA

Amphipods were the most abundant animals at Moxie location where they made up more than 50% of the invertebrates at the one and two meter buoys on the six common sampling dates (Table 15). Densities as great as 22,000 per square meter were found at the two meter buoy in August 1985. Two species were present, Gammarus lacustris and the smaller and more abundant Hyallela azteca. During July and August, times of high water, 83% of all amphipods were collected at the one and two meter buoys. During low water periods, large increases in amphipod density were observed at the 3, 4 and 5 meter buoys, suggesting that many amphipods moved there. Mann-Whitney U tests showed significant differences in the density of amphipods at the 3, 4 and 5 meter buoys between times of high and low water for the two years when winter samples were collected (p = 0.0001). However, the total number of amphipods on the transect may not have changed significantly between high and low water periods in those two years. A Mann-Whitney U test comparing the total number of amphipods collected at all depths during the high water period of June to October 1984 with that of the following low water period of December 1984 to April 1985 showed no significant difference (p=0.56). A similar result (p=0.51) was found for a comparison of the high and low water periods of the following year.

Table 15. Percent of invertebrates that were amphipods in samples collected on the six common sampling dates.

Depth, m	Rainy Lake		Namakan Reservoir		
	Harrison	Black	Moxie	Junction	Swanson
1	4.0	30.0	54.5	10.0	3.6
2	0.6	0.5	56.2	2.0	7.5
3	0.0	0.1	30.6	0.0	0.0
4	0.0	*	16.2	0.2	0.0
5	0.3	**	6.2	0.5	0.0

(* only two sampling dates; ** no samples)

The change in amphipod density between high and low water periods was not simply the result of animals moving so as to remain at the same depth. There was a major shift of amphipods from shallow to deeper water between August and October 1984 when the water level declined by 0.393 meters (15.5 inches). The same magnitude of change occurred between August and October 1985 when the water level fell only 0.08 meter (3 inches) (Table 16).

Table 16. Mean number of amphipods per square meter at Moxie location August to October 1984 and April to October 1985.

	Sampling Buoys Depth, m				
Date	1	2	3	4	5
Aug. 84	11,739	989	1,376	0	0
Oct. 84	1,548	4,171	6,450	3,956	9,159
Apr. 85	0	43	129	3,784	2,408
May 85	1,032	1,376	3,870	2,795	1,247
June 85	2,451	2,580	516	989	602
July 85	10,664	3,440	6,880	1,376	387
Aug. 85	20,554	22,016	4,171	2,193	301
Sept.85	2,967	5,332	4,171	1,419	215
Oct. 85	1,376	4,257	5,762	5,891	7,052

The increase in amphipod density at the one and two meter buoys from early spring to August appeared to be only partially due to a shift of animals away from the 4 and 5 meter buoy areas. Spectacular reproductive growth probably also occurred at the shallower depths (Table 16).

CHIRONOMIDS

Chironomids may be favored by drawdown. Chironomid larvae quickly recolonized newly submerged areas when water returned after drawdown in a Missouri River reservoir (Cowell and Hudson 1968). Grimas (1961) found that the percent of chironomids in samples from Lake Blasjon increased from 32% to 54% following ten years of increased winter drawdown. Nearby unregulated lakes showed no change. The average density of chironomids at the three Namakan Reservoir locations was greater than that at the two Rainy Lake locations at all sample depths. The difference in density was greatest at one meter (Table 17). This suggests that increased drawdown in Namakan Reservoir caused an increase in chironomid density. The percent of chironomids in samples from each depth at the five study locations is given in Table 18. Swanson location had higher percentages of chironomids than Rainy Lake locations at all depths. Junction had a higher percentage only at the one meter depth. Moxie had higher percentages at three to five meters, but lower percentages at one and two meters where amphipods made up more than 55% of the invertebrates.

Table 17. Mean number of chironomids per square meter for the six common sampling dates.

	Rainy Lake			Namakan Reservoir			
Depth	Harrison	Black	mean	Moxie	Junction	Swanson	mean
1	2,083	1,237	1,660	3,536	4,047	3,106	3,577
2	1,488	922	1,205	2,269	1,011	2,714	1,863
3	511	941	726	2,253	373	1,500	973
4	418	*	418	2,492	475	522	514
5	377	**	377	2,286	334	702	518

(* two sampling dates; ** no samples.)

Table 18. Percent of invertebrates that were chironomids in samples taken on the six common sampling dates.

	Rainy Lake			Namakan Reservoir			
depth	Harrison	Black	mean	Moxie	Junction	Swanson	mean
1	35.8	26.4	31.1	24.7	63.6	66.4	51.6
2	32.7	51.3	42.0	26.0	23.2	67.9	39.0
3	38.2	29.7	34.0	45.3	35.1	53.9	44.8
4	39.5	34.4*	37.0	51.6	37.3	61.8	50.2
5	46.6	**	46.6	50.5	32.1	52.0	44.9

(* two sampling dates; ** no samples.)

Due to time limitations, it was not possible to identify chironomids to genus in all the samples collected. However, this was done for 19 samples from Moxie and 15 samples from Harrison. The Moxie samples contained a total of 30 genera while the Harrison samples contained 31 genera. Twenty-one genera were found at both locations, 9 genera were found only in Moxie samples and 10 only in Harrison samples (Appendix D). The genus Glyptotendipes had the highest density at Moxie location, but it was not found at Harrison. Pinder and Reiss (1983) state that Glyptotendipes occurs in detritus-rich littoral sediments. Sephton et al. (1983) reported that it is an early colonizer of reservoirs and usually declines after initial colnization. The question of whether Glyptotendipes great abundance at Moxie and absence from Harrison was due to differences in sediment detritus or was a result of increased drawdown may be answered when the chironomids from Black, Junction and Swanson locations are examined.

Of the 10 genera that were found only at Harrison, three, Labrundinia, Lauterborniella and Psectrocladius, are reported to prefer or occur only in small bodies of water (Pinder and Reiss 1983). The one meter sampling area at Harrison where these genera were collected is in a very narrow, protected portion of the bay. This area probably has the characteristics of a small water body which Moxie location lacks. The genera Stictochironomus, which was abundant at Moxie and absent from Harrison, and Pseudochironomus, which was the most abundant genus at one meter at Moxie, are said to prefer sandy substrates (Pinder and Reiss 1983). Sandy habitat was present at one meter at Moxie but did not occur at Harrison. Those genera with densities greater than 100 per square meter are listed in Table 19.

Table 19. Number per square meter of the twelve chironomid genera with densities greater than 100 at Moxie or Harrison. Genera marked with an asterisk were found at only one of the locations.

	One meter depth		Three meter depth	
	Harrison	Moxie	Harrison	Moxie
Genera				
Cladotanytarsus	65	500	86	27
Clinotanypus	0	5	0	250
Cricotopus*	0	161	0	0
Endochironomus	108	5	43	27
Glyptotendipes*	0	452	0	989
Parakiefferiella	22	280	0	0
Polypedilum	376	16	129	153
Procladius	322	177	43	813
Psectrocladius*	151	0	0	0
Pseudochironomus	22	521	43	12
Stictochironomus*	0	376	0	121
Tanytarsus	376	344	43	395

ASELLUS

The most striking difference between the invertebrate communities of Rainy Lake and the Namakan Reservoir lakes was the complete absence of the isopod genus Asellus from Namakan Reservoir. Pennak (1978) states that freshwater isopods seldom come into open water but remain hidden under rocks, vegetation or debris and are restricted to unpolluted shallows, rarely being found in water more than a meter deep. Asellus were found regularly at the one meter depth at Harrison and Black locations (Table 20) but were never collected at Moxie, Junction or Swanson locations. Grimas (1961) found that Asellus disappeared entirely from Lake Blasjon after regulation. Reynoldson (1961) reported that Asellus density was positively correlated with calcium and dissolved solids, so on the basis of water chemistry, one would expect to find higher densities of Asellus at Moxie in Kabetogama Lake than in Rainy Lake. Their tendency to remain concealed may prevent them from moving in response to changing water levels.

It seems likely that this genus was eliminated from the Namakan Reservoir lakes by abnormal winter drawdown.

Table 20. Mean number of Asellus per square meter at the two Rainy Lake locations for the six common sampling dates. This genus was never found at the Namakan Reservoir locations.

Depth, m	Harrison	Black	mean
1	853	563	708
2	10	5	8
3	0	0	0
4	0	*	0
5	2	**	2

(* two sampling dates; ** no samples.)

SIALIS

The alderfly Sialis also disappeared from Lake Blasjon after regulation (Grimas 1961). Sialis were found at all five Voyageurs locations, but density was quite low at the one meter depth at all locations and at the one and two meter depths at the Namakan Reservoir locations, suggesting that their density was greatly reduced in the drawdown zone (Table 21). Wilcoxon Signed Rank tests showed that at the two meter sampling depth, the number of Sialis at Black location was significantly greater than at all three Namakan Reservoir locations, and the number at Harrison was significantly greater than at Moxie and Swanson (Table 22). At three meters, there were no significant differences in the number of Sialis between the Rainy Lake and Namakan Reservoir locations. At four and five meters there were no significant differences between Harrison and the Namakan Reservoir locations. The test could not be performed on the one meter samples because of too many tied zero samples.

Table 21. Mean number of Sialis per square meter for the six common sampling dates.

	Rainy Lake			Namakan Reservoir			
Depth, m	Harrison	Black	mean	Moxie	Junction	Swanson	mean
1	2	2	2.0	0	2	0	0.7
2	29	65	47.0	0	12	0	4.0
3	26	10	18.0	12	14	22	16.0
4	50	*	50.0	24	24	38	28.7
5	38	**	38.0	45	22	28	31.7

(* two sampling dates; ** no samples.)

Table 22. Results of Wilcoxon Signed Rank two tailed tests of *Sialis* in all summer samples.

Two meters

	Harrison	Black	Moxie	Junction
Black	.1004			
Moxie	.0357	.0007		
Junction	.1380	.0010	.0588	
Swanson	.0357	.0010	*	.2250

Three meters

	Harrison	Black	Moxie	Junction
Black	.1763			
Moxie	.2937	.2937		
Junction	.2362	.4756	.1835	
Swanson	.8339	.6363	.1082	.3671

Four meters

	Harrison	Black	Moxie	Junction
Black	---			
Moxie	.8068	---		
Junction	.2027	---	.3004	
Swanson	.7051	---	.5049	.3280

Five meters

	Harrison	Black	Moxie	Junction
Black	---			
Moxie	.5354	---		
Junction	.8939	---	.0910	
Swanson	.8336	---	.7175	.1422

* too many ties to perform test.

HEXAGENIA

Large Hexagenia mayfly nymphs were the most conspicuous invertebrates found dead in samples of dewatered sediment. Hexagenia nymphs construct U-shaped burrows in the sediment and may become trapped in their burrows when water levels fall. Average mean density of Hexagenia at the two Rainy Lake locations was greater at all depths than that at the three Namakan Reservoir locations (Table 23). The difference in density was greatest at depths of one and two meters where the average density at the Namakan Reservoir locations was only 6% of that at the Rainy Lake locations. This indicates a reduction of more than 90% in the drawdown zone. At three meters the number of Hexagenia at Junction was greater than at Black and at five meters the number at Junction and Swanson exceeded that at Harrison. Table 24 shows that the number of Hexagenia collected at Harrison location was significantly greater than at Moxie at all five sample depths and significantly greater than at Swanson at all except the five meter depth. The number of Hexagenia was greater at Harrison than at Junction location at all depths except five meters, but the difference was statistically significant only at three meters.

Table 23. Mean number of Hexagenia per square meter for samples collected on the six common sampling dates.

	Rainy Lake			Namakan Reservoir			
Depth, m	Harrison	Black	mean	Moxie	Junction	Swanson	mean
1	53	158	105.5	2	17	0	6.3
2	151	296	223.5	0	110	2	37.3
3	277	124	200.5	57	158	103	106.0
4	225	*	225.0	17	196	69	94.0
5	179	**	179.0	24	194	201	139.7

(* two sampling dates: ** no samples.)

Table 24. Results of Wilcoxon Signed Rank two tailed tests of *Hexagenia* in summer samples.

One meter

	Harrison	Black	Moxie	Junction
Black	.3066			
Moxie	.0354	.0149		
Junction	.2340	.1166	.0222	
Swanson	.0078	.0140	*	.0140

Two meters

	Harrison	Black	Moxie	Junction
Black	.1550			
Moxie	.0007	.0001		
Junction	.1448	.0034	.0002	
Swanson	.0009	.0001	*	.0002

Three meters

	Harrison	Black	Moxie	Junction
Black	.0201			
Moxie	.0014	.0058		
Junction	.0415	.8276	.0163	
Swanson	.0043	.1626	.1088	.3272

Four Meters

	Harrison	Black	Moxie	Junction
Black	.0588			
Moxie	.0003	.0140		
Junction	.8160	1.0000	.0002	
Swanson	.0010	.0140.	.0176	.0041

Five meters

	Harrison	Black	Moxie	Junction
Black	---			
Moxie	.0003	---		
Junction	.4632	---	.0004	
Swanson	.6607	---	.0002	.9851

* too many ties to perform test.

CAENIS

When drawdown was decreased in Lake Francis Case in South Dakota, Benson and Hudson (1975) found that the mayfly *Caenis* increased greatly, suggesting that drawdown had adversely affected its density. *Caenis* were found at all five Voyageurs transects with the highest density always at one meter (Table 25). At Harrison and Black locations in Rainy Lake, the density at one meter was 3.5 and 10 times, respectively, the total density of the other four sampling depths. At Moxie, Junction and Swanson locations, the density at one meter was 1.1, 1.6 and 0.9 times, respectively, that of the total density of the other four sampling depths. If the 3.5 proportion at Harrison had occurred at the Namakan Reservoir locations, the density at one meter would have been 1,069 at Moxie, 749 at Junction and 1,380 at Swanson. Based on this assumption, the densities of *Caenis* in Namakan Reservoir at one meter were reduced 54 to 74%.

Table 25. Mean number of *Caenis* per square meter for the six common sampling dates.

	Rainy Lake			Namakan Reservoir			
Depth, m	Harrison	Black	mean	Moxie	Junction	Swanson	mean
1	757	191	474.0	325	346	354	341.7
2	167	17	92.0	57	96	179	110.7
3	33	2	17.5	57	43	172	90.7
4	7	*	7.0	96	69	10	58.3
5	7	**	7.0	93	5	31	43.0

(* two sampling dates; ** no samples.)

Wilcoxon Signed Rank tests showed that at one meter depth, the number of *Caenis* at Junction was significantly greater than at Black (Table 26). At two meters the number at Harrison, Junction and Swanson was significantly greater than at Black and the number at Swanson significantly greater than at Moxie. At three meters the number at Swanson and Moxie were significantly greater than at Black and the number at Swanson significantly greater than at Junction. At four meters the number at Moxie was significantly greater than at Harrison and Swanson, and at five meters the number at Moxie was significantly greater than at Harrison, Junction and Swanson.

Table 26. Results of Wilcoxon Signed Rank two-tailed tests on the number of Caenis in all summer samples.

One meter

	Harrison	Black	Moxie	Junction
Black	.0878			
Moxie	.3203	.1475		
Junction	.3455	.0383	.4925	
Swanson	.2897	.0878	.7939	.9851

Two meters

	Harrison	Black	Moxie	Junction
Black	.0016			
Moxie	.1140	1.0000		
Junction	.6665	.1182	.0452	
Swanson	.7269	.0122	.0465	.1322

Three meters

	Harrison	Black	Moxie	Junction
Black	.0627			
Moxie	.3455	.0182		
Junction	.6115	.1072	.6115	
Swanson	.0933	.0037	.1166	.0250

Four meters

	Harrison	Black	Moxie	Junction
Black	---			
Moxie	.0206	---		
Junction	.0799	---	.2478	
Swanson	.8929	---	.0040	.0525

Five meters

	Harrison	Black	Moxie	Junction
Black	---			
Moxie	.0106	---		
Junction	.7893	---	.0020	
Swanson	.2049	---	.0141	.1380

GASTROPODA

At Harrison and Black locations in Rainy Lake, the maximum density of snails was at one meter with an average of 82% collected at that depth. At the three Namakan Reservoir locations, the maximum density was at two meters, and an average of only 26% were collected at one meter (Table 27). Grimas (1961) found a more extreme shift in Lake Blasjon, where six meter winter drawdown caused the elimination of gastropods from depths of less than 4 meters. Total gastropod density at Harrison location was 1.24 times greater than at Moxie and

Junction and 3.27 times greater than at Swanson. This suggests that drawdown caused reductions of 19 and 70% at these locations, respectively. At Harrison the density of snails at one meter was 4.96 times the total density of the other four sampling depths. If this proportion had occurred at the Namakan Reservoir locations the density at one meter at Moxie, Junction and Swanson would have been 3,094, 960, and 344 respectively. Based on this assumption, snail density at one meter at Namakan Reservoir locations was reduced from 54 to 88%. However, the density of snails at two meters was considerably greater at Namakan Reservoir locations than at Rainy Lake locations and therefore, drawdown may have caused a shift in density rather than a reduction.

Table 27. Mean number of gastropods per square meter for the six common sampling dates.

	Rainy Lake			Namakan Reservoir			
Depth, m	Harrison	Black	mean	Moxie	Junction	Swanson	mean
1	996	387	691.5	387	387	158	310.7
2	172	22	97.0	1527	545	179	750.3
3	22	79	50.5	272	29	22	107.7
4	0	0*	0.0	50	0	7	19.0
5	7	**	7.0	22	7	0	9.7

(*two sampling dates; ** no samples.)

CONCLUSIONS

Results of this study indicate that increased drawdown in Namakan Reservoir altered the benthic invertebrate community in several ways. Relatively large numbers of animals became stranded and died each year. At least one group, the isopod genus Asellus, appeared to have been completely eliminated from the Namakan Reservoir lakes. Other groups including Caenis, Gastropoda, Hexagenia, and Sialis suffered reductions in density. Chironomid density may have increased. Diversity was lowered in the Namakan Reservoir lakes, particularly in the drawdown zone. Total invertebrate density in Namakan Reservoir lakes appeared to be more variable in the drawdown zone and to often be reduced in spring and early summer. Density at the Reservoir locations was significantly higher in June and August 1985, the year during the study with the least drawdown. The examination of the remaining chironomid samples and detailed studies of other groups may identify other effects of drawdown. Considerable variation in factors such as morphometry, wind exposure and sediment type between the five locations studied may have obscured additional effects of drawdown.

The intensity of the alterations in the invertebrate community caused by drawdown is likely to be directly correlated with the magnitude of drawdown. The invertebrate community in Lake Blasjon (Grimas 1961) where a six meter winter drawdown occurred was more altered than that in Namakan Reservoir which is subjected to a 2.5 meter drawdown. A reduction in drawdown in Namakan Reservoir should result in an amelioration of the drawdown effects observed in this study, and any increase will undoubtedly cause further changes.

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APPENDIX A

The number of individuals in each taxon for each invertebrate sample. The three replicate Ekman grabs are indicated as A, B and C. The grab sampled a surface area of 0.0232 square meters. To convert the number of organisms in a grab to a square meter basis, multiply by 43.056.

Harrison Bay 1 Meter

	June 84			July 84			August 84			June 85			August 85			June 86		
Agraylea	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Amphipoda			2	21	7	4		4	2	1		2	2	3	37	7		
Asellus				4	1				1	32	28	76	58	57	34	27	26	13
Banksiola																		
Caenis	6	3			1					90	78	25		5	6	53	27	23
Callibaetis				1								1	6					
Ceratopogon	3	1		9	11	2		3	1	7	9	3	4	2	1	5	3	15
Chaoborus	1	1	1							1	4	1		1		1		1
Chironomidae	46	20	18	91	74	5	5	47	29	37	59	25	62	55	185	29	37	48
Climacia																		
Chrysops	1		1	2														
Coleopters																1		
Didymops																		
Dubiraphia																		
Enallagma									1						5			
Gastropoda	2	4	1		4			2	2	10	10	87	8	5	2	1		1
Hexagenia						2				7	8	1				1	2	1
Hirudinea	2	1	1	3	1	2			5	3			1	1	3		1	
Hydracarina										3	2		1	2	2		1	
Hydroporus																		
Mollana										1								
Mystacides									1	1	3		1			1	1	
Nematoda											1		1					2
Oecetis										4	4	1		1		6	2	
Oligochaeta	1		6	33	17	3	1	16	3	9	7	8	22	4	15	11	2	43
Oxyethira								1	1									
Perithemis														1	4			
Phylocentro														1				
Phryganea															2			
Platyhelmin																		
Polycentrop	3	1												7	5	1		
Porifera							1		1				3		3			1
Sialis																		1
Sphaeriidae	3	1	1		5			3	2	34	58	18	5	17	40	10	9	18
Tetrogoneuria													2					
Trich Pupa																		
Undet Odoneta	1																	
Total Ind.	69	32	31	164	121	18	7	76	49	240	271	248	176	162	344	153	111	167

HARRISON 2 METERS

	JUNE 84			JULY 84			AUGUST 84		JUNE 85			AUGUST 85			JUNE 86		
	A	B	C	A	B	C	B	C	A	B	C	A	B	C	A	B	C
Amphipoda	1	1		4		3					1			1			1
Asellus											2					2	
Banksiola																	
Caenis	4		1	1			1		4	1	6	5	1	3	14	15	14
Callibaetis																	
Ceratopogon	4	1	5	4	9	5	1	6	10	11	11	10	1	4	34	26	15
Chaoborus	7	6	15	3	1		34	48		2	5	19	16	6	6	14	8
Chironomidae	80	10	39	49	19	28	25	23	44	53	37	17	13	18	48	61	59
Climacia				2							1						
Chrysops						5											
Didymops																	
Dubiraphia																	1
Enallagma																	
Gastropoda	2					6			3	6	1	2		3			1
Hexagenia			3	1	1	1	4	4	8	7	12	4	7	7	1	1	2
Hirudinea	1					2						1			2	1	1
Hydracarina														1		1	
Hydroporus																	
Mollana																	
Mystacides																	1
Nematoda									5	2	2	2		3	15	11	7
Oecetis												2	1				
Oligochaeta	4						54	28	103	84	33	28	8	75	44	48	52
Oxyethira																	
Perithemis																	
Phylocentro						3	1			1		1	1	2			
Phryganea														1			
Platyhelmin																	
Polycentrop								1								1	
Porifera									1					2	1		1
Sialis	3		2			1						1	3	2			
Sphaeriidae	4		1	3	1	6			7	2	3	6	1	6	19	27	14
Other	1					1									1	1	
Total Ind.	111	18	66	67	31	61	120	110	185	169	114	98	52	134	185	209	177

HARRISON BAY 3 METERS

	JUNE 84		JULY 84			AUGUST 84			JUNE 85			AUGUST 85			JUNE 86		
	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Amphipoda																	
Asellus																	
Banksiola																	
Caenis	1	1									1				5	3	3
Callibaetis																	
Ceratopogon			1	1			1		1				2	1	1	2	1
Chaoborus		1			1	2	2		5	1		5	4	5	2	2	1
Chironomidae	1	5	8	5		25	27	16	19	15	24	4	3	4	18	17	23
Climacia																	
Chrysops																	
Didymops																	
Dubiraphia																	
Enallagma																	
Gastropoda								1			1	1					
Hexagenia	9	2	1	5	3	10	14	6	2	1	11	6	12	9	10	8	7
Hirudinea																	
Hydracarina							1					2	1	1		1	
Hydroporus																	
Mollana																	
Mystacides																	1
Nematoda						1	1	2		2		1	4	2		1	4
Oecetis							1						1				1
Oligochaeta						4	5	4	3	1	2	1	8	13	13	18	27
Oxyethira																	
Perithemis																	
Phylocentro							1										
Phryganea																	
Platyhelmin																	
Polycentrop																	
Porifera																	
Sialis			1			1	2	2	1					3		1	
Sphaeriidae								1	1	4	5	2	7		1	4	7
Other															1		

HARRISON 4 METERS

	JUNE 84			JULY 84			AUGUST 84			JUNE 85			AUGUST 85			JUNE 86		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Amphipoda																		
Asellus																		
Banksiola																		
Caenis											1							2
Callibaetis																		
Ceratopogon	2			1	2	1					3		2	12			2	
Chaoborus	8	2	5	2	1		3	21	10	3	5	1	4		5	3	2	5
Chironomidae	4	3	4	15	12	13	15	9	8	8	29	15	10	4	2	2	12	10
Climacia																		
Chrysops																		
Didymops																		
Dubiraphia																		
Enallagma																		
Gastropoda																		
Hexagenia	4	8	4	2	3	2	4	4		3	10	5	4	7	8	9	4	12
Hirudinea																		
Hydracarina											1		2				2	2
Hydroporus																		
Mollana																		
Mystacides																		
Nematoda													1	3		1	1	4
Oecetis													1					
Oligochaeta				4			1			2	2	4	2					1
Oxyethira																		
Perithemis																		
Phylocentro																		
Phryganea																		
Platyhelmin																		
Polycentrop																		
Porifera																		
Sialis						1	2	1		3	2	6	1	1	2	1		1
Sphaeriidae			2	2								1	1	3	1			
Other					1													
Total Ind.	18	13	15	26	19	17	25	35	18	19	53	32	28	30	18	16	23	37

HARRISON 5 METERS

	JUNE 84			JULY 84			AUGUST 84			JUNE 85			AUGUST 85			JUNE 86		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Amphipoda		1			1													
Asellus																1		
Banksiola																		
Caenis	1															1	1	
Callibaetis																		
Ceratopogon	10											1						
Chaoborus	16			1			3	5	1	1		2	2	1	3		2	1
Chironomidae	67	4	1	6	3	6	7	4	14	4	13	6	3	6	4	3	5	2
Climacia										2	1							
Chrysops																		
Didymops																		
Dubiraphia																		
Enallagma																		
Gastropoda	1																	
Hexagenia	3	3	3	3	3	1	3	5	4	1	7	6	2	4	2	3	16	6
Hirudinea					2	1												
Hydracarina										1			4	2		1		
Hydroporus																		
Mollana																		
Mystacides																		
Nematoda												1	1	2				
Oecetis																		
Oligochaeta								1		2	2	3						
Oxyethira																		
Perithemis																		
Phylocentro																		
Phryganea																		
platyhelmin																		
Polycentrop																		
Porifera														1				
Sialis	4					1	1		1	1	1	3	1	1	1			1
Sphaeriidae	2										1	1		1		1		
Other	1																	
Total Ind.	105	8	4	10	9	9	14	15	20	12	25	23	13	18	10	10	24	10

BLACK 1 METER

	SEPTEMBER 83			JUNE 84			JULY 84			AUGUST 84			JUNE 85			AUGUST 85			JUNE 86		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Amphipoda	96	8	37	4	3		55	26	68	107	61	37	1	2		105	76	12	4	23	2
Asellus	45	63	109				12	6	53	31	26	6				38	29	6	4	21	4
Banksiola																					
Caenis			1			1				35	33	3				1	3	1		3	
Callibaetis																					
Ceratopogon			1	2			3		5	2	5	3		2	1	2	5		1	3	1
Chaoborus										4											
Chironomidae	31	91	9	5	2	4	45	3	29	137	75	77	14	11	1	18	41	16	17	7	16
Climacia																					
Chrysops								1								1					
Didymops																					
Dubiraphia																					
Enallagma			1																		
Gastropoda				10	1		11		10	4	2		2	5	2	2	1	2	1		1
Hexagenia					1					27	14	13					3		4	2	2
Hirudinea	1	1	1				3	2	2	1											
Hydracarina											1								1		
Hydroporus			1																		
Mollana																			1		
Mystacides																					
Nematoda						1				4					1	2		5		8	1
Oecetis	1				1									1				1			
Oligochaeta	3	8	6	12	15	7	7		15		5	3	45	54	36	9	9	17	7	4	6
Oxyethira																					
Perithemis																					
Phylocentro																					
Phryganea	6		1																		
Platyhelmin																					
Polycentrop	8	12	5															3			
Porifera																					
Sialis						1															
Sphaeriidae							9		3	2	6		4	15	1	2	16	2	7	14	10
Other																					

BLACK 2 METERS

	SEPT. 83			JUNE 84			JULY 84			AUGUST 84			JUNE 85			AUGUST 85			JUNE 85		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Amphipoda		3	1							2									2		
Asellus							1												1		
Banksiola																					
Caenis	7	3	4							2						2		1	2		
Callibaetis																					
Ceratopogon	2		2	3	3	2				1		1	1					1	3	1	4
Chaoborus				1	6	2				1	2	3			1	1	1	1		1	2
Chironomidae	58	157	79	16	18	25	13	16	20	33	57	32	24	8	23	27	16	14	19	18	7
Climacia																					
Chrysops																					
Didymops																					
Dubiraphia																					
Enallagma																					
Gastropoda	2												1	1	1						
Hexagenia	7	38	24	6	3	5	7	11	6	32	14	9	5	3	2	2	3	5	4	1	6
Hirudinea																					1
Hydracarina	2	1									1			1					2		
Hydroporus																					
Mollana																					
Mystacides																					
Nematoda												1	1	1	1	1		1			
Oecetis																					
Oligochaeta	9	3	6	1	1	11	1		5	1		3	18	21	20	1		1	6	10	9
Oxyethira																					
Perithemis																					
Phylocentro																					
Phryganea																					
Platyhelmin																					
Polycentrop																					
Porifera																					
Sialis	3	1	1	1	1	1				1	2	6			1	3	2	6	2	1	
Sphaeriidae				8		2	2						9	2	2				5	1	6
Other																					
Total Ind.	90	206	117	36	32	48	24	27	31	73	76	55	59	37	51	37	22	30	46	33	35

BLACK 3 METERS

	AUGUST 83			JUNE 84			JULY 84			AUGUST 84			JUNE 85			AUGUST 85			JUNE 86		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Amphipoda			1										1								
Asellus																					1
Banksiola																					
Caenis	2												1								
Callibaetis																					
Ceratopogon						2		2	2	3	2			1			1			2	1
Chaoborus			56	8	4	9	1	1		19	18	29	4	6	5	10	23	28	8	4	1
Chironomidae	79	79	38	38	25	16	17	21	10	16	103	21	14	11	9	19	20	27	6	15	6
Climacia																					
Chrysops																					
Didymops																					
Dubiraphia																					
Enallagma																					
Gastropoda				1					4			1				2		3			
Hexagenia	5	10	7		3		3	2	1				9	5	6	10	3	4	1	4	1
Hirudinea				2			1						1								
Hydracarina													1		1		3	2	1	1	
Hydroporus																					
Mollana																					
Mystacides																					
Nematoda										1			2	1	5	12	1	3	5	1	5
Oecetis				1																	
Oligochaeta	6			50	25	22	9	7	9	27	46	27	40	3	9	56	35	88	22	12	5
Oxyethira																					
Perithemis																					
Phylocentro																					
Phryganea																					
Platyhemin																					
Polycentrop									1												
Porifera																					
Sialis	2	2	3										1					1	2		
Sphaeriidae		1		6	3				1		1		4	9	15	23	18	17	14	3	4
Other																					
Total Ind	94	92	105	106	60	49	31	33	28	66	170	78	78	36	50	132	104	173	59	42	24

BLACK 4 METERS

	SEPTEMBER 83			JUNE 85			AUGUST 85		
	A	B	C	A	B	C	A	B	C
Amphipoda									
Asellus									
Banksiola									
Caenis									
Callibaetis									
Ceratopogon	2							4	
Chaoborus	51	70	82	7	7	11	4	3	11
Chironomidae	14	28		13	21	24	26	38	26
Climacia									
Chrysops									
Didymops									
Dubiraphia									
Enallagma									
Gastropoda									
Hexagenia	17		6	9	13	7	9	10	8
Hirudinea									
Hydracarina					1				2
Hydroporus									
Mollana									
Mystacides									
Nematoda					2	2	1	1	2
Oecetis									
Oligochaeta	5	5	1	14	19	14	18	16	19
Oxyethira									
Perithemis									
Phylocentro									
Phryganea									
Platyhelmin									
Polycentrop									
Porifera									
Sialis	4	11	10	2	2	4	22	12	17
Sphaeriidae						9			
Other									
TOTAL IND	93	114	99	45	65	71	80	84	85

MOXIE 1 METER

	August 83			June 84			July 84			August 84			Oct. 84		Dec. 84	May 85			June 85			July 85		
	A	B	C	A	B	C	A	B	C	A	B	C	B	C	A	A	B	C	A	B	C	A	B	C
Agraylea																								
Amphipoda	104	93	183	33	105	21	312	210	174	200	308	204	30	42	1	27	15	30	73	57	40	95	255	393
Asellus																								
Banksiola																								
Caenis	1	8	2							23	19	12	3			3	12	20	2	10	4		1	
Callibaetis	1	2	1							1	2	2												
Ceratopogon							1	2	1	7	15	9	42	17		3	1	2		6		2	3	
Chaoborus					2									1					1					
Chironomidae	7	2	13	1		15	59	16	33	200	248	193	126	40	1	178	67	106	35	108	41	199	76	90
Climacia																								
Chrysops																								
Didymops																								
Dubiraphia		1					2			1	2													
Enallagma										1	2	5												
Gastropoda				18	6			1	1			1	1	2		6	2	19	6	1	3	9	4	5
Hexagenia																						1		
Hirudinea				1	3			1				2	1	1									1	
Hydracarina	1									1						1				1	1			
Hydroporus																								
Mollana												1									1			
Mystacides											2													
Nematoda										4	3	2	3	1	6	12	7	11	3	10	5	6	10	11
Oecetis	4	1	1		2					1				1			2		2	5	3	1	1	1
Oligochaeta	1	11	3				20	7	41	11	10	8	15	22		17	10	8	3	2	1	11	5	35
Oxyethira											1													
Perithemis																								
Phylocentro																								
Phryganea		1																						
Platyhelmin																								
Polycentrop							1					1												
Porifera																								
Sialis																								
Sphaeriidae		2				1	2	1	2	3			2			9	6	5	53	75	18	74	26	41
Tetrogoneuria																								
Trich Pupa																								
Undet Odoneta														1										
Total Ind.	119	121	203	35	128	45	397	238	252	453	612	440	221	128	8	256	122	201	178	275	117	398	382	576

MOXIE 1 METER

	August 85			Sept. 85			October 85			Dec. 85		June 86		
	A	B	C	A	B	C	A	B	C	B	C	A	B	C
Agraylea	1													
Amphipoda	438	588	407	64	103	41	27	17	51			39	45	15
Asellus														
Banksiola							2		2	1				1
Caenis	25	36	4	5	6	1	2	3	3					1
Callibaetis		1												
Ceratopogon	6	8	5			1		1	4			6	4	
Chaoborus									2				4	3
Chironomidae	154	167	131	237	108	99	219	33	315	12	3	32	19	28
Climacia														
Chrysops														
Didymops														
Dubiraphia		3						1						
Enallagma	8	4						1						
Gastropoda	11	3	3	2		2	12	5	13		1			
Hexagenia			1	2		1								
Hirudinea								1	1					
Hydracarina			11											
Hydroporus														
Mollana		3	4			3	5		2	2		1		
Mystacides	2	2												
Nematoda	21	19	23	1						1		8	2	5
Oecetis	2	3	1	2			7							
Oligochaeta	31	28	16	13	7	35	3	7	12	1	9	14	13	9
Oxyethira														
Perithemis														
Phylocentro														
Phryganea			2						1					
Platyhelmin														
Polycentrop														
Porifera						1								
Sialis														
Sphaeriidae	173	162	42	4		3	1	2	1		3	24	8	3
Tetrogoneuria	1													
Trich Pupa														
Undet Odoneta														1
Total Ind.	872	1027	650	330	224	187	278	71	407	17	16	124	95	66

Moxie 2 Meters

	August 83			June 84			July 84			August 84			October 84			December 84			January 85			February 85			ApR 85			May 85		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Agraylea																														
Amphipoda	202	66	89	2	7	15	16	38	99	20	23	26	79	90	122	67	40	16	83	26	30		1	1		3		37	18	40
Asellus																														
Banksiola																3									1				1	
Caenis						1									1				4	6	1				3		6	9	10	20
Callibaetis									1				2																	
Ceratopogon	1		1	5	5				5			1		4	4	3	4			3	3		3	4	1	1	1	3	1	
Chaoborus				1	1														1									1	1	1
Chironomidae	16	21	5	48	67	120	4	10	24	22	18	21	58	71	90	42	77	55	96	75	120	28	70	68	72	100	72	64	50	144
Climacia																														
Chrysops																														
Didymops																														
Dubiraphia																														
Dyticid Larva																														
Enallagma																														
Gastropoda	1			25	15	49	4	5	49	2	3	2	3	4	22	5	1	1	29	30	22	1			10	40	37	28	18	46
Hexagenia																														
Hirudinea	3		1						3	4	1	4	2	1	1		2								1·		1		2	1
Hydracarina										1											1						1	2		1
Hydroporus																														
Lep. Larva																														
Mollana			2							1									2		1					2		1		
Mystacides																			1											
Nematoda								1	2	1									1	2		1	4	4		3	1	1	1	4
Oecetis	1				3	3									3				2							2	2		5	3
Oligochaeta		2	1				5	1	3	2	1	1	1	17	1	6	7	7	15	6	2		2		2		3	10	5	12
Oxyethira																														
Paraponyx		1										3		1																
Perithemis																														
Phylocentro								2																						
Phryganea											1			1			1													
Platyhelmin																														
Polycentrop																														
Porifera																														
Sialis																														
Sphaeriidae				1	3	3	9			8				2	4				21	4	6				3		6		3	20
Trichopbra		1										3		1																
Trichop Pupa										1																				
Total Ind.	224	90	99	82	101	167	38	57	186	61	47	59	145	191	248	126	131	79	255	152	186	30	80	77	93	151	130	156	115	292

Moxie 2 Meters

	June 85			July 85			August 85			Sept. 85			October 85			December 85			January 86			February 8		March 86	April 86			June 86		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	B	C	A	A	B	C	A	B	C
Agraylea																														
Amphipoda	66	44	70	19	26	195	458	611	468	189	61	123	125	120	52	99	34	50	50	44	11	1	1		47	26	11	30	30	32
Asellus																														
Banksiola																3		1							2	1		1		
Caenis		1	2				5	5	10	4		1	4	2	1															
Callibaetis							2		2																					
Ceratopogon	15	1	1		2	8	8	4	6	2		5	2	2		2	9	2	2	2	14		1		11	8	8	2	1	1
Chaoborus		1						1			2			5	3	1								1				1	2	6
Chironomidae	94	53	90	37	34	36	153	61	112	27	24	15	42	68	30	33	17	16	13	18	9		2		24	20	19	23	26	4
Climacia																														
Chrysops																														
Didymops																														
Dubiraphia																														
Dyticid Larve								1	1																					
Enallagma						1	2	2				1	1	3					1											
Gastropoda	8	18	18	7	5	117	8	19	10	7	3	9	16	8	12	19	22	14	16	12	6				13	9	21	1		1
Hexagenia					1	1					1				1															
Hirudinea			4		1	5	2	3	1		1	3	1		2		1	1	2	2							1	1		
Hydracarina	1		1	1			4	5																	1	2	5			1
Hydroporus																														
Lep. Larva							1																							
Mollana		1			1		1		3	5			3			1	1	1								2		3	3	2
Mystacides								1	1					1			1									1				
Nematoda	6	6	1	1	2	3	3			1											2					5	2	2	2	
Oecetis			1	1	1	1		2	3	1																				
Oligochaeta	12	25	41	5		8	18	16	23	4	4	5	21	26	9	2		15	6	7	3		1		9	11	6	12	6	6
Oxyethira																														
Paraponyx																														
Perithemis																														
Phylocentro																														
Phryganea										1																				
Platyhelmin																														
Polycentrop																														
Porifera																														
Sialis																														
Sphaeriidae	10	8	7	13	3	8	9	7	3	4	14		4	1	4	1		1							5	3	7	1		
Trichopbra							1	1	1																					
Trichop Pupa																														
Total Ind.	212	158	236	85	76	394	674	738	643	245	110	162	219	236	114	161	100	92	91	81	42	1	5	1	112	88	80	77	70	53

Moxie 3 M

	AUGUST 83		JUNE 84			JULY 84			AUGUST 84			OCTOBER 84			DEC. 84		JANUARY 85			FEBRUARY 85			MARCH 85			Ap
	A	B	A	B	C	A	B	C	A	B	C	A	B	C	A	C	A	B	C	A	B	C	A	B	C	A
Amphipoda	3		13	17	35	14	3	10	28	34	35	75	230	144	83	69	130	162	146	20	82	154	383	75	98	3
Asellus																										
Banksiola																										
Caenis		1							2	5	1	2		6	40		16	27	16	2	3	20	33	23	26	2
Callibaetis															1											
Ceratopogon	2	15					1				1		1	2		2	4	4	3	1	3		2	2	2	2
Chaoborus	4	3	8	5	8				4	11	4															
Chironomidae	112	107	25	42	51	42	28	73	62	151	100	51	61	59	48	62	85	95	91	29	85	98	142	88	80	71
Climacia																										
Chrysops																										
Didymops																										
Dubiraphia																										
Enallagma																										
Gastropoda	8	12				10	3	7			1	4	1	1	3	9	21	65	51	3	23	53	365	70	76	35
Hexagenia						1	2		1	1	1	1	1	5	1	4	8	2	2	1	3	1	14	3	3	
Hirudinea		1			2				1		1	1	3	2		1		2		1	1	1	1			
Hydracarina																	1			1			2			
Hydroporus																										
Mollana						1				1						3	2				2	1	11	1	1	1
Mystacides																										
Nematoda						2				8	8	2	1	3				2		6	2	7		14	11	2
Oecetis								1																		
Oligochaeta		2				8	8	7		11	5	4	1	4			10	9	9	11	13	14	8	20	7	10
Oxyethira																										
Perithemis																										
Phylocentro																										
Phryganea											1															
Playhelmin																										
Polycentrop																										
Porifera																										
Sialis									4					1					1				1		1	
Sphaeriidae	1	3					3	10	6	24	9	2			1		8	23	11	4	5	29	39	15	24	11
Other																										
Total Ind.	130	144	56	67	103	68	45	102	108	246	167	142	299	247	177	150	285	391	330	79	222	378	100	311	329	137

Moxie 3 M

			May 85			June 85			JULY 85			August 85			SEPTEMBER 85			OCTOBER 85			DECEMBER 85			JANUARY 86			FRBRUARY	
	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.
Amphipoda	3	3	90	132	48	16	44	7	231	80	169	118	134	40	123	81	86	262	54	86	219	198	102	175	182	228	25	38
Asellus																												
Banksiola																		1			1							
Caenis	5	1	8	12	9	2	5	3	2	1		2	3			4		2	5	3	1	7		9	6	6		
Callibaetis																												
Ceratopogon	2		4		2		2	2	5	1	3	2		3	1	3	2		3	1	4	6	4	3	7	2		1
Chaoborus			1	1		4		1	5	11	9	2	4	3	5		1											
Chironomidae	27	37	54	79	65	53	65	50	59	12	38	61	56	56	41	21	29	13	29	31	46	63	55	67	37	46	65	18
Climacia																												
Chrysops																												
Didymops																												
Dubiraphia																												
Enallagma																1												
Gastropoda	37	19	6	14	7	4	4	1	3	1	7		1			2		2		1	16	6	10	3	14	13	5	3
Hexagenia			1	4	2	3	4	3		1	1	4	3		6	6	1	1	4	4	3	4	6	3	8	4	7	4
Hirudinea			1	2		1			1	2		2					1						1		3	1		1
Hydracarina				3	1	2			1			1	2									2			1			
Hydroporus																												
Mollana		1					1					2							1		1							
Mystacides																												
Nematoda	6		6	4	24	8	1	4	3	1		1					1					2			6		1	
Oecetis												1		3						1								
Oligochaeta	7	7	10	10	6	4		7	7	1	1	5	3	4	1	3	1	5	8	5	10	14	17	23	19	16	12	5
Oxyethira																												
Perithemis																												
Phylocentro																												
Phryganea																			1									
Playhelmin																												
Polycentrop																												
Porifera																												
Sialis				3									1						1				1	1				
Sphaeriidae	14	5	22	22	23	33	12	22	55	1	10	17	18	16	1	1	2	1	1	2				2	4	3		
Other						1			1																			
Total Ind.	101	73	203	286	187	131	138	100	373	112	238	218	225	125	178	122	124	287	107	134	301	302	196	286	287	319	115	70

Moxie 3 M

		MARCH 86			APRIL 86			JUNE 86		
	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.
Amphipoda	40	41	34	25	149	159	133	34	52	2
Asellus										
Banksiola										
Caenis	2			5	2	8				1
Callibaetis										
Ceratopogon	2	2	2	3	2	4	2		2	1
Chaoborus	2								3	2
Chironomidae	64	46	44	61	17	24	25	13	3	12
Climacia										
Chrysops										
Didymops										
Dubiraphia										
Enallagma										
Gastropoda	8	1			5	1			3	4
Hexagenia	7	8		8			1	1		
Hirudinea			1					2		1
Hydracarina										
Hydroporus										
Mollana									1	
Mystacides										
Nematoda			1	1		1	1	1		
Oecetis										
Oligochaeta	22	9	5	9	7	5	12	3	8	11
Oxyethira										
Perithemis										
Phylocentro										
Phryganea					1					
Playhelmin										
Polycentrop										
Porifera										
Sialis										
Sphaeriidae	2		5	3	1	2		3		3
Other										
Total Ind.	149	107	92	115	184	204	174	57	72	37

MOXIE 4 METERS

	AUGUST 83			JUNE 84			JULY 84			AUGUST 84			OCTOBER 84			DECEMBER 84			JANUARY 85			FEBRUARY 85			MARCH 85		APRIL 85		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	A	B	C
Amphipoda	6	10	43	16	35	25		5					10	202	63	28	84	115	33	123	35	43	111	41	73	93	60	99	105
Asellus																													
Banksiola																													
Caenis	3	3	1									2		5					1	41	3	7	12	7	2	6	7	9	19
Callibaetis																													
Ceratopogon				6	2	2	3	1	2	1			2	1			3		2	3	2	9	7	3	7	9	1	3	1
Chaoborus	26	6	2	15	5	2		1	3	21	9	13	3	7	8	3	5	6	3			2		1	2	1	1	4	2
Chironomidae	69	64	32	61	39	41	9	88		61	27	63	5	80	42	27	40	33	22	69	28	68	96	61	39	83	61	65	59
Climacia																													
Chrysops																													
Didymops																													
Dubiraphia																													
Enallagma																													
Gastropoda		1		2										1							4					2	2	3	8
Hexagenia			2	2		1		1					1									2							
Hirudinea	1			1		1		7	3	4				2	1						1			1		2			
Hydracarina		1																	3		3		1	1	3	2	2	2	1
Hydroporus																													
Mollana																													
Mystacides																													
Nematoda			3																2	2		3	8		1	7	2	3	1
Oecetis																													
Oligochaeta	4	3	6							10	2	12	1	7	2		5	4	12	16	9	24	37	13	10	13	16	12	12
Oxyethira																													
Perithemis																													
Phylocentro																													
Phryganea															1														
Platyhelmin																													
Polycentrop																													
Porifera																													
Sialis	1									2	3	1	2	1			1		1			1	1		1		1		
Sphaeriidae				1		4	1	39	2	5	1			9	3	7	1		7	30	10	14	45	20	10	23	26	34	49
Other																													
Total Ind.	110	88	89	104	81	76	15	142	12	104	42	91	24	315	120	65	139	158	86	284	95	173	318	148	148	241	179	234	257

MOXIE 4 METERS

	MAY 85			JUNE 85			JULY 85			AUGUST 85			SEPTEMBER 85			OCTOBER 85			DECEMBER 85			JANUARY 86			FEBRUARY 8-	
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B
Amphipoda	56	104	35	9	32	27	14	11	71	118	25	10	35	1	63	354	31	25	182	166	163	130	293	234	149	74
Asellus																										
Banksiola																			1	1						
Caenis	4	4	6	2	10	13		1	1	3	5	4			1	35	1			3			4	1		
Callibaetis																										
Ceratopogon	4	1	8	4	4	7	2		1	14	6	2	7	3	1	2	5		1		3	1	5			2
Chaoborus	2	4	5	5	5	7	19	17	8	3	5	9	1	5	4	1			1	3	5	2	1	2		
Chironomidae	80	36	75	45	100	101	26	33	37	151	112	87	48	18	14	55	8	5	52	53	54	39	48	61	25	22
Climacia																										
Chrysops																										
Didymops																										
Dubiraphia																										
Enallagma		2																								
Gastropoda	1		3		2	1	2		2		1	1				1			3	1	1		2			1
Hexagenia					1	1										1	1	1	1	1	1		2		1	
Hirudinea	1			1	2	1		4	7	1	2		1			4				1	1		1	1	2	
Hydracarina	2	1	1	1					2	4	1		1							2	1				2	
Hydroporus																										
Mollana																										
Mystacides																										
Nematoda	13	5	24	3	12	7	1		3											1						
Oecetis																										
Oligochaeta	20	4	19	9	15		7	2	16	7	17	13	5	4	2	4	1			2	1		1	1		
Oxyethira																										
Perithemis																										
Phylocentro						1																				
Phryganea																								1		
Platyhelmin																										
Polycentrop																										
Porifera										1																
Sialis		1								1	2								1		1			1		
Sphaeriidae	49	5	12	32	33	26	4	5	13	22	22	19	4	4	5	12			3	11	2	1	12	8	2	1
Other																										
Total Ind.	232	167	188	111	216	192	75	73	161	325	198	145	102	35	90	469	47	31	246	245	233	173	369	310	181	100

MOXIE 4 METERS

		MARCH 86			APRIL 86			JUNE 86		
	C	A	B	C	A	B	C	A	B	C
Amphipoda	346	262	200	201	301	206	306	1	8	16
Asellus										
Banksiola										
Caenis	8	6			1	3				1
Callibaetis										
Ceratopogon		3	6	3	7	3		5	2	4
Chaoborus	2	1						4	3	4
Chironomidae	65	46	46	56	27	27	21	7	17	34
Climacia										
Chrysops										
Didymops										
Dubiraphia										
Enallagma										
Gastropoda				2						
Hexagenia		2	3				2		1	
Hirudinea			1	1	1	3	2			
Hydracarina			1			1				
Hydroporus										
Mollana										
Mystacides										
Nematoda			1				1		5	1
Oecetis										
Oligochaeta	2	1	4	2	3	4	6	3	7	7
Oxyethira										
Perithemis										
Phylocentro										
Phryganea										
Platyhelmin										
Polycentrop										
Porifera										
Sialis										1
Sphaeriidae	8	9	2	30	2	1		9	18	12
Other										
Total Ind.	431	330	264	295	342	248	338	29	61	80

MOXIE 5 METERS

	AUGUST 83			JUNE 84			JULY 85			AUGUST 84			OCTOBER 84			DECEMBER 84			JANUARY 85		
	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	B.	C.	D.	A.	B.	C.
Amphipoda	1			3		3		4					121	347	172	46	56	24	50	68	36
Asellus																					
Banksiola																					
Caenis	8	1	2								3	1	6	49	7	1	1		28	28	11
Callibaetis																					
Ceratopogonidae			2	2	2				2		1	1	1		1				2	3	
Chaoborus	7	4	9	10	14	22	6	2	6	10	14	14	16	20	23	13	12		4	6	2
Chironomidae	77	59	43		18	44	37	25	27	69	70	51	31	48	38	16	22	10	64	67	47
Climacia																					
Chrysops																					
Didymops																					
Dubiraphia																					
Enallagma																					
Gastropoda	2					1											1	3			1
Hexagenia		1			1			2	1		2	1		1	1		2				
Hirudinea	2		1	1	2												1				
Hydracarina													1		2				2		
Hydroporus																					
Mollana																					
Mystacides																					
Nematoda										2				3					23	2	1
Oecetis																					
Oligochaeta	11	2	7							5	2	3		3			1	1	17	15	10
Oxyethira																					
Perithemis																					
Phylocentropus																					
Phryganea																					
Platyhelminthes																					
Polycentropus																					
Porifera																					
Sialis	1	3			1					4	2	3	1	1	1		4	1		1	
Sphaeriidae	1	6		3		1	23	8					1	3	2				8	4	2
Tetragoneuria																					
Undet.Odonata																					
other																					
total ind	110	76	64	19	38	71	66	41	36	90	94	74	178	475	247	76	100	39	198	194	109

Moxie 5m

	FEBRUARY 85			MARCH 8			APRIL 85			MAY 1985			JUNE 85			JULY 85			AUGUST 85			SEPT
	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.
Amphipoda	27	47	18	70	101	75	32	46	90	22	44	22	16	13	14	12	4	12			20	
Asellus																						
Banksiola																						
Caenis	9	13	7	15	33	81	26	14	18		3	4	9	4	5				3	1	4	
Callibaetis											1											
Ceratopogonidae	2		1	5	1	1		1		5	1	1		7	5	4	3		3		6	6
Chaoborus	1				1	1			1	7		9	18	10	8	4	1	2	2	10	3	9
Chironomidae	43	53	55	62	70	63	39	56	60	21	40	34	102	71	63	27	25	14	96	128	87	46
Climacia																						
Chrysops																						
Didymops																						
Dubiraphia																						
Enallagma																						
Gastropoda						1	1		2											1		
Hexagenia					1						1	2								1		1
Hirudinea												1	1							2		
Hydracarina	5	4	4	3	7	5	5	3	2		3		2		2	1			1			
Hydroporus																						
Mollana																						
Mystacides																						
Nematoda	1	1	2	26	9	1	5	135	36		1	1	6	2	5	2	9	1	4			2
Oecetis																						
Oligochaeta	7	13	11	11	12	11	11	11	8	4		2	57	42	65	6	12	3	25	25	42	16
Oxyethira																						
Perithemis																						
Phylocentropus																						
Phryganea																						
Platyhelminthes																						
Polycentropus																						
Porifera																						
Sialis	3		1				1	2	1	1	3	1	2	1			1	1		2	2	
Sphaeriidae	4	3		12	6	8	9	5	16	3	3	12	13	9	9	1	3	3	21	23	18	7
Tetragoneuria																						
Undet.Odonata																						
other																						
total ind	102	134	99	204	241	247	129	270	232	63	100	89	226	159	176	57	58	36	155	193	182	87

Moxie 5m

	SEPT 85		OCTOBER 85				DECEMBER 85				JANUARY 86				FEBRUARY 86				MARCH 86				APRIL 86
	B.	C.	A.	B.	C.	D.	A.	B.	C.	D.	A.	B.	C.	D.	A.	B.	C.	D.	A.	B.	C.	D.	A.
Amphipoda	14		117	267	96	176	125	186	185	81	190	207	101	212	221	270	136	157	204	241	207	220	32
Asellus																							
Banksiola																							
Caenis			2	21		9			3		13	24	11	3			11		3	7		1	3
Callibaetis																					1		
Ceratopogonidae			2	2												1	1			1			
Chaoborus	4	2		2	3	2	3	7	3	2	5	3		1	1		1	1					
Chironomidae	10	9	26	41	18	25	43	48	46	21	43	61	40	28	44	33	51	35	51	51	31	46	4
Climacia																							
Chrysops																							
Didymops																							
Dubiraphia																							
Enallagma																							
Gastropoda	1							1														1	
Hexagenia				1		1			2		1	4	1	2	1		2	2	2	1			1
Hirudinea				2	2			1		1					1			1				1	
Hydracarina								1	2			2								3			
Hydroporus																							
Mollana																							
Mystacides																							
Nematoda	1																	1					
Oecetis																							
Oligochaeta	5	4	13	7	2	6	3	4	1	1	4	5		3		2	10	2	1	6	3	11	63
Oxyethira																							
Perithemis																							
Phylocentropus																							
Phryganea																							
Platyhelminthes																							
Polycentropus																							
Porifera																							
Sialis	2	1		1	3	2	1	2			2	3	2		1	2				1			
Sphaeriidae		4		1	4	11	3	3		2	3	7	1	4		6	5	2	2	9	2	10	
Tetragoneuria																							
Undet.Odonata																							
other																							
total ind	37	20	160	345	128	232	178	253	242	108	261	316	156	253	269	314	217	201	263	320	244	290	103

Moxie 5m

	APRIL 86			JUNE 86		
	B.	C.	D.	A.	B.	C.
Amphipoda	224	198	390	18	21	6
Asellus						
Banksiola						
Caenis	8	7		1	8	
Callibaetis						
Ceratopogonidae	1	4	1	7	4	1
Chaoborus	3	2		21	5	13
Chironomidae	25	26	21	26	33	10
Climacia						
Chrysops						
Didymops						
Dubiraphia						
Enallagma						
Gastropoda					1	
Hexagenia			1		1	1
Hirudinea						
Hydracarina		1			4	
Hydroporus						
Mollana						
Mystacides						
Nematoda	3		1	2	10	
Oecetis						
Oligochaeta	19	32	25	15	34	3
Oxyethira						
Perithemis						
Phylocentropus						
Phryganea						
Platyhelminthes						
Polycentropus						
Porifera						
Sialis	1				1	1
Sphaeriidae	5	4	24	9	17	3
Tetragoneuria						
Undet.Odonata						
other						
total ind	289	273	463	99	139	38

JUNCTION BAY 1 METER

	AUGUST 83			JUNE 84			JULY 84			AUGUST 84			JUNE 85			AUGUST 85			JUNE 86		
	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.
Amphipoda	70	25	28	23		2	7	4	7	3	4	1	1	1	1	89	65	61	2	4	2
Asellus																					
Banksiola																					
Caenis	8	2			3			1		5	2	19	13	8	8	32	20	10	2	12	10
Callibaetis																				1	1
Ceratopogon		1			5		2		2				4	2	6	10	2		5	5	5
Chaoborus														1						1	
Chironomidae	22	2	17	7	12		150	110	208	9	7	29	135	96	98	293	126	164	58	122	70
Climacia												2									
Chrysops														1	2						1
Didymops																					
Dubiraphia																					
Enallagma																					
Gastropoda						10	7	11	2		4	2	7	8					1	2	
Hexagenia			3			1						1	1					1	1	1	1
Hirudinea								1					1	2		6	1	8	1	2	
Hydracarina																2	1			2	5
Hydroporus														1							1
Mollana														2		1		2	1		
Mystacides												1				6		1		1	
Nematoda													5	5	4	1	2	1	2		6
Oecetis	7	3	4							2		2	2	4		2	4	3	1	6	
Oligochaeta	5		2				2	12	23	1	3	5	14	11	21	12	8	14	15	27	27
Oxyethira												1									
Perithemis																					
Phylocentro																	1				
Phryganea																					
Platyhelmin																					
Polycentrop											1	1			1	2		2			
Porifera															2			1	1		1
Sialis	1																	1			
Sphaeriidae							3	3		4	7		10	11	7	3	20	14	5	15	11
Other	2		2									1	1			1					
Total Ind.	115	33	56	30	20	13	171	142	242	24	28	65	194	153	150	460	250	283	95	201	141

JUNCTION BAY 2 METERS

	AUGUST 83			JUNE 84			JULY 84			AUGUST 84			JUNE 85			AUGUST 85			JUNE 86		
	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.
Amphipoda		1			1	1		9	17			1	1	3		2		1		3	
Asellus																					
Banksiola																					
Caenis		2	1	1		1				1		3	4	4	4	10	4	6		2	
Callibaetis																					
Ceratopogon				1	2	1			5	1	1	2	34	5	19	15	2		1	3	1
Chaoborus										52											1
Chironomidae	11	6	5	16	4	7	50		18	38	37	51	63	37	27	23	14	13	8	11	6
Climacia																					
Chrysops																					
Didymops																		2			
Dubiraphia																					
Enallagma		1																			
Gastropoda		4				2	4		13	4	2		7	20		6	9	9			
Hexagenia	7	2	1	5			1		1	4	1	2	3	2	2	2	12	6	2	2	1
Hirudinea										2	2	2			1	1	1				
Hydracarina										1		3	2				1	1		1	1
Hydroporus																					
Mollana															1						
Mystacides														1			4			1	
Nematoda												2	5	1	1	1		2	1	1	3
Oecetis		1								1			3	4		1	3	6	1		
Oligochaeta	7	10	4					1	36	60	31	68	128	146	50	121	91	85	24	26	15
Oxyethira																					
Perithemis																					
Phylocentro										1						2	3				
Phryganea																					
Platyhelmin																					
Polycentrop											4										
Porifera											1	1									
Sialis	1	1														1	1	3			
Sphaeriidae					1		1	1	15	2	1	2	10	11		10	21	5	5	7	1
Other															1						
Total Ind.	26	28	11	23	8	12	56	11	105	167	80	137	260	234	106	195	166	139	42	57	29

Junction Bay 3 Meters

	August 83			June 84			July 84			August 84			June 85			August 85			June 86		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Amphipoda																					
Asellus																					
Banksiola																					
Caenis	1	5	1							2		1				1	14				
Callibaetis																					
Ceratopogon		1	1			4	4		4				1		1	2	6	3		1	4
Chaoborus		1								1	1	1			1				4	2	4
Chironomidae	9	15	19	6	1	15	9	44	5		8	3	2	7	11	14	17	6	3	3	2
Climacia																					
Chrysops																					
Didymops														1							
Dubiraphia																					
Enallagma																					
Gastropoda				2				2													
Hexagenia	2	1	5	2	1	5			1	1	1	7	1	3	9	10	15	4	2		4
Hirudinea									3												1
Hydracarina																			1		
Hydroporus																					
Mollana																	2				
Mystacides													1			1					
Nematoda											1										1
Oecetis																	1				
Oligochaeta	8	6	13				20		30	2	1	1	2		7	13	16	7	3	4	6
Oxyethira																					
Perithemis																					
Phylocentro										2						2	1				
Phryganea																					
Platyhelmin																					
Polycentrop																					
Porifera																					
Sialis	1		1	1		1						1	1		1		1				
Sphaeriidae								2	3	1		1		3	2			1	3		4
Undet Odenata							1														
Total Ind.	21	29	40	11	2	25	34	48	46	9	12	15	8	14	32	43	73	21	16	10	26

JUNCTION BAY 4 METERS

	AUGUST 83			JUNE 84			JULY 84			AUGUST 84			JUNE 85			AUGUST 85			JUNE 86		
	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.
Amphipoda						1															
Asellus																					
Banksiola																					
Caenis	1	1									9	2				3	11	3		1	
Callibaetis																					
Ceratopogon	1	3	3			1			2		4		4	9	6	5	4	1		1	1
Chaoborus	8	3	7	2		2	5		4		2	1	1		1		1	4	11	7	4
Chironomidae	11	22	20	27	7	18	4	1	6		4	6	16	25	24	18	21	8	4	6	4
Climacia																					
Chrysops																					
Didymops																					
Dubiraphia																					
Enallagma																					
Gastropoda																					
Hexagenia	7	5	9	8	1	5	2	2	3	1	1	3	4	7	8	10	12	14		1	
Hirudinea											1					1					
Hydracarina														1		1	1				
Hydroporus																					
Mollana														1		1	1				
Mystacides																					
Nematoda																			1		1
Oecetis																	1		1		
Oligochaeta	2	6	1								3	2	4	20	12	16	21	6	2	6	2
Oxyethira																					
Perithemis																					
Phylocentro														2	1	1	5				
Phryganea																					
Platyhelmin																					
Polycentrop												1									
Porifera																					
Sialis	3											1			1	3	4	1			
Sphaeriidae			1										1	2	1	3	1	2	1	2	
Other																					
Total Ind.	33	40	41	37	8	27	11	3	15	1	24	16	30	67	54	62	83	39	20	24	12

Junction Bay 5 Meters

	August 83			June 84			July 84			August 84			June 85			August 85			June 86		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Amphipoda						2															
Asellus																					
Banksiola																					
Caenis				1									1								
Callibaetis																					
Ceratopogon						1							3			1		1			1
Chaoborus	1	1	2	6	5	6	1		2					3	5	13	18	10	19	2	27
Chironomidae	1		1	11	13	16	5	22	1			1	10	10	18	3	2	4	6	2	16
Climacia																					
Chrysops																					
Didymops																					
Dubiraphia																					
Enallagma																					
Gastropoda													1								
Hexagenia	8	5	8	8	3	6	4	4	1				2	9	14	6	10	5	6		3
Hirudinea																					
Hydracarina															1	1	2	3			1
Hydroporus																					
Mollana																					
Mystacides																					
Nematoda													1								1
Oecetis														1			1				
Oligochaeta	1	1	2										8	6	1	4	6	12	3		7
Oxyethira																					
Perithemis																					
Phylocentro																					
Phryganea																					
Platyhelmin																					
Polycentrop																					
Porifera																					
Sialis	1	1			1	1										1	1	2	2		1
Sphaeriidae									1			1	1	3	7	1	3	1			
Total Ind.	12	8	13	26	22	32	10	26	5			2	27	32	46	30	43	38	36	4	57

SWANSON BAY 1 METER

	AUGUST 83			JUNE 84			JULY 84			AUGUST 84			JUNE 85			AUGUST 85			JUNE 86		
	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.
Amphipoda	2	6	3					1		1	2	2		3	2	15	23	18		3	1
Asellus																					
Banksiola			1																		
Caenis	3	1		1	3	6					2		7	32	43	6	2	6	2	23	17
Callibaetis														3	1						
Ceratopogon		1	1	2	2							1	4		7	11	4	4		5	
Chaoborus																					
Chironomidae	10	23	18	25	207	113	11	15	9	10	7	38	74	138	137	173	36	30	8	155	114
Climacia																					
Chrysops				2											1	1	1	1			
Didymops																					
Dubiraphia																					
Enallagma		1														2		1			
Gastropoda					1				1			1	1		5	3	3	6			1
Hexagenia																					
Hirudinea				1	1	1		1		1	1	1	1	1	2	3	1	3		2	2
Hydracarina												1	1	1	4		1	3			
Hydroporus																		1			
Mollana																					
Mystacides											1										
Nematoda											2	1	2	1	1		1	2			
Oecetis	3	1	1	1	1							1	2	10	5	2	3	3	1	1	6
Oligochaeta	6	1	2				12	13		8	14	5	10	18	13	17	6	13		13	4
Oxyethira																1	2				
Perithemis																1	2				
Phylocentro																					
Phryganea											2										
Platyhelmin																					
Polycentrop	2	1	1																		
Porifera													1			2	1		1		
Sialis																					
Sphaeriidae			2			1	10	6	1	2	2	1	9	2	6	62	2	11	2	7	2
Other	2	1																			
Total Ind.	28	36	29	32	215	121	33	36	11	22	33	52	112	209	227	299	88	102	14	209	147

SWANSON BAY 2 METERS

	AUGUST 83			JUNE 84			JULY 84			AUGUST 84			JUNE 85			AUGUST 85			JUNE 86		
	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.
Amphipoda	2						51	25	46		1					1	1				
Asellus																					
Banksiola																					
Caenis	18	4	10	25	4					1	1		16	15	4			.	1	2	6
Callibaetis	1																				
Ceratopogon	1	1		2				8				2	1	1	1		1	2			1
Chaoborus	2		1	1		1					1	1			3					1	2
Chironomidae	99	161	162	35	10	5	2	28	3	18	43	22	200	249	245	105	95	35	3	10	28
Climacia																					
Chrysops																					
Didymops																					
Dubiraphia																					
Enallagma																2	2	1			
Gastropoda	1						2						3	1	6	6	3	4			
Hexagenia	1				1																
Hirudinea								1	3	1			1	1			4	1			
Hydracarina	1												1	5			3				
Hydroporus																					
Mollana													1	1	2		1				
Mystacides																					
Nematoda									3				3	6	6	12		3	2	12	3
Oecetis										1			6		1	1					
Oligochaeta			1					11	4		1			3	8	8	13	4	3	2	12
Oxyethira																					
Perithemis																					
Phylocentro													1			2	3				
Phryganea																					
Platyhelmin																					
Polycentrop	1	1		1						1	1		1					8			
Porifera		1	1												1		1				
Sialis																					
Sphaeriidae	1		1				3		4		3	1	13	18	10	5	6	6	4	11	18
Other												1									
TOTAL IND.	128	168	176	64	15	6	58	73	63	22	51	27	247	300	287	142	133	64	13	38	70

SWANSON BAY 3 METERS

	AUGUST 83			JUNE 84			JULY 84			AUGUST 84			JUNE 85			AUGUST 85			JUNE 86		
	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.
Amphipoda																					
Asellus																					
Banksiola																					
Caenis	15									1	5	6	5	3	1	11	19	20	1		
Callibaetis																					
Ceratopogon					1		2		3	1	1			5	1	4	1		2		1
Chaoborus	12	2	7	1	1					1	2		2		2	13	19	6			1
Chironomidae	16	4	11	11	11	15	16	12	13	35	56	58	43	77	70	33	105	64	4		5
Climacia																					
Chrysops																					
Didymops																					
Dubiraphia																					
Enallagma																					
Gastropoda														1		2					
Hexagenia	3	1	2	1	1		3	1	3	3	9	8	3	5	5						1
Hirudinea										1							1		1		
Hydracarina												1	1			2	3	7			
Hydroporus																					
Mollana																					
Mystacides																					
Nematoda									1				1	2			1				
Oecetis							1							2				1			
Oligochaeta	5	1			4		17		28	11	9	13	4	6	2	17	17	4	2	1	7
Oxyethira																					
Perithemis																					
Phylocentro	4	1								2		1									
Phryganea																					
Platyhelmin																					
Polycentrop			1											1			1				
Porifera																					
Sialis		1	3		2					3	2	2									
Sphaeriidae			1				6	1	3	1			13	22	13	33	27	27	3	1	16
Other																	1				
Total Ind.	55	10	25	13	20	15	45	14	51	59	84	89	72	124	94	115	195	129	13	2	31

SWANSON BAY 4 METERS

	AUGUST 83			JUNE 84			JULY 84			AUGUST 84			JUNE 85		AUGUST 85			JUNE 86		
	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	C.	A.	B.	C.	A.	B.	C.
Amphipoda																				
Asellus																				
Banksiola																				
Caenis				1										2		1				
Callibaetis																				
Ceratopogon												1	1		1	1	1		1	1
Chaoborus	1		1		2	1					1			5	2		1			
Chironomidae	23	7	20	27	19	19	6	2	5	23	7	5	15	39	13	21	21			9
Climacia																				
Chrysops																				
Didymops										1										
Dubiraphia																				
Enallagma																				
Gastropoda					1															
Hexagenia	2			3	3		1	2		1	3	1	3	6		3		2		1
Hirudinea			1												1		2			
Hydracarina													1				1			
Hydroporus																				
Mollana																				
Mystacides																				
Nematoda																				
Oecetis					1					1						1				
Oligochaeta	5		1			4	5					1	5	10	2	4		4	5	1
Oxyethira																				
Perithemis																				
Phylocentro										2					1		1			
Phryganea																				
Platyhelmin																				
Polycentrop																				
Porifera																				
Sialis	1	1		1		2	1						2	2	2	2	1		2	
Sphaeriidae							1	1					2	6	2	2	1	3		
Other																				
Total Ind.	32	8	23	32	26	26	14	5	5	29	11	10	29	70	24	35	29	9	8	12

SWANSON BAY 5 METERS

	AUGUST 83			JUNE 84			JULY 84			AUGUST 84			JUNE 85			AUGUST 85			JUNE 86		
	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.
Amphipoda																					
Asellus																					
Banksiola																					
Caenis					2								2	2	7						
Callibaetis																					
Ceratopogon						2					1			1			1	2		2	
Chaoborus	4		5	3	1	6	1				3	2	1		2	2	3	1			1
Chironomidae	12	12	15	8	33	37	7	9	12	9	12	12	41	23	34	19	19	16	3	8	3
Climacia																					
Chrysops																					
Didymops																					
Dubiraphia																					
Enallagma																					
Gastropoda																					
Hexagenia	5	4	8	11	7	4	2	2	3	4	6	7	9	2	10		4	2		9	2
Hirudinea																					
Hydracarina													2		2	1	1	3			
Hydroporus																					
Mollana																					
Mystacides																					
Nematoda																					
Oecetis														1	1						
Oligochaeta							3	13	3	1	2	1	6	6	3	5	5	9	10	1	2
Oxyethira																					
Perithemis																					
Phylocentro	1									1	1					1	2				
Phryganea																					
Platyhelmin																					
Polycentrop																					
Porifera																					
Sialis	2	1	2	1		5			1				2	1	1	3	1	1			
Sphaeriidae							1	1					7	5	6	5	5	5			2
Other																					
Total Ind.	24	17	30	23	43	54	14	25	19	15	25	22	70	41	66	36	41	39	13	20	10

APPENDIX B

The mean number of taxa per sample for the six common sampling dates.

One Meter	June 84	July 84	Aug 84	June 85	Aug 85	June 86	Average	Rank
Harrison	10	8.7	8	14.3	15.7	13	11.6	1
Black	5.3	7	9	6	9.7	9.3	7.7	5
Moxie	4	6.7	11.7	9.7	12.7	7.3	8.7	3
Junction	2.7	6	8.3	12	13	13.3	9.2	2
Swanson	5.3	3.7	8	10.7	14.3	7	8.2	4
Rainy Lake Ave.	7.7	7.9	8.5	10.2	12.7	11.2	9.7	1
Namakan Res. Ave.	4	5.5	9.3	10.8	13.3	9.2	8.7	2
Two Meters								
Harrison	7	8	6	10.3	12.7	12.3	9.4	1
Black	6.7	3.3	6.7	7.3	6.3	8	6.4	5
Moxie	6.3	6.3	7	9.7	12.7	8.7	8.5	2
Junction	4.3	4.7	10.3	9.7	13	8.3	8.4	3
Swanson	3.3	5	5.7	11	9.3	6	6.7	4
Rainy Lake Ave.	6.9	5.7	6.4	8.8	9.5	10.2	7.9	1.5
Namakan Res. Ave.	4.6	5.3	7.7	10.1	11.7	7.7	7.9	1.5
Three Meters								
Harrison	3.5	3	7.7	6.3	8.3	9	6.3	3.5
Black	5.3	5.7	4.6	8.3	8	8	6.7	2
Moxie	3.3	6.3	9	10.3	10	7.7	7.8	1
Junction	3.3	4	6	5.7	7.3	6	5.4	5
Swanson	3.3	5	8	8.3	8.7	4.7	6.3	3.5
Rainy Lake Ave.	4.4	4.4	6.2	7.3	8.2	8.5	6.5	1.5
Namakan Res. Ave.	3.3	5.1	7.7	8.1	8.7	6.1	6.5	1.5
Four Meters								
Harrison	3.7	4.7	3.7	6.3	7	6.3	5.3	3
Black				6.3	6.7			
Moxie	6.3	4.7	5.7	10.7	10.3	7.7	7.6	1
Junction	3.3	3	5	7.3	10.3	6	5.8	2
Swanson	4.3	3	5	7	8	3.3	5.1	4
Rainy Lake Ave.	3.7	4.7	3.7	6.3	6.9	6.3	5.3	2
Namakan Res. Ave.	4.6	3.6	5.2	8.3	9.5	5.7	6.2	1
Five Meters								
Harrison	4.7	3.7	4	7	6	4.7	4	4
Black								
Moxie	5.3	4	6.3	9.3	8.3	9.3	7.1	1
Junction	4.7	2.5	3	6.7	8	5	5	3
Swanson	4.3	4.4	4.7	8.3	8	3.4	5.5	2
Rainy Lake Ave.	4.7	3.7	4	7	6	4.7	4	2
Namakan Res. Ave.	4.8	3.6	4.7	8.1	8.1	5.9	5.9	1

APPENDIX C

The number of individuals in each taxon for samples collected at holes cut through the ice at Moxie location on March 1, 1984. The holes are identified by their distance from shore because no buoys were in place at this time.

No. of invertebrates per square meter, March 1,1984

Distance from shore, m	46	91	137	137	187	229	229	274	274	457	518	610	610
Depth in cm.	0	0	0	0	10	10	10	15	15	46	91	122	122
Amphipoda			7320	43	258	431	258	4822	560	7147	7276	10032	2196
Caenis		172	947			43		43		86	86	43	517
Ceratopogonidae			258		86			43			86		43
Chaoborus												43	43
Chironomidae		1464	6071	129	388	258	431	172		1292	1593	1414	775
Gastropoda		43	4004		86	129		517	86	215	129	43	
Hexagenia			129									86	129
Hirudinea		43	86		43		86			86			86
Hydracarina						43					86	43	
Nematoda		86						129					
Oecetis			43										
Oligochaeta			431			86	86		129			345	129
Sialis			43							43			
Sphaeriidae		258	4951		43	129		43		258	517	215	129
Total	0	2066	24283	172	904	1119	861	5769	775	9343	9773	12221	4047

APPENDIX D

The number of individuals in each chironomid genus present in 19 samples from Moxie and 14 samples from Harrison

	Harris One M	Moxie One M	Harris Two M	Harris Three M	Moxie Three M	Harris Four M	Harris Five M
Ablabesmyia	97	43	17		35		14
Chironomus	54		9		47		
Cladopelma	43		17				
Cladotanytarsus	65	500	95	86	27	22	57
Clinotanypus		5	232		250	22	129
Coryneura		5					
Cricotopus		161					
Cryptochironomus	32	81	9		39	22	14
Cryptotendipes				86	4	22	14
Dicrotendipes	43	48			67	22	
Einfeldia	22				12		
Endochironomus	108	5	292	43	27		201
Epoicocladius			52		4		
Glyptotendipes		452			989		
Harnischia			9				
Labrundinia	11						
Larsia			9				
Lauterborniella	11						
Micropsectra		11					
Microtendipes	32	5			4		
Nannocladius	11	11					
Nilothauma	22			43			
Orthocladius		59					
Parachironomus	11	5					
Parakiefferiella	22	280					
Paralauterborniella			9				
Paratanytarsus	32	70	9				
Paratendipes		5			16		
Pagastiella	11		26		63		14
Polypedilum	376	16	292	129	153		43
Procladius	322	177	267	43	813	22	244
Psectrocladius	151						
Pseudochironomus	22	521	9	43	12		14
Stempellina			9	43			
Stempellinella		97	9		20		
Stictochironomus		366			121		
Tanypus			26				
Tanytarsus	376	344	163	43	395	22	244
Tribelos					4		
Natarsia					4		
undetermined		11	26	43			

Appendix E

Percent organic content in sediment samples collected in August 1983, June 1984, June 1985 and August 1985 at depths of 1, 2, 3, 4 and 5 meters. NS indicates no sample analyzed.

Depth, m

Harrison

	8/83	6/84	6/84	6/84	6/85	6/85	6/85	8/85	8/85	8/85
1	NS	50.9	50.5	51.5	73.9	NS	NS	55.4	55.5	55.7
2	NS	13.5	14.2	40.4	19.0	19.3	NS	15.5	16.1	15.4
3	NS	2.6	2.4	2.7	2.2	NS	NS	2.4	2.4	2.5
4	NS	2.4	3.4	3.1	3.1	NS	NS	5.5	5.4	5.6
5	NS	5.4	4.1	5.3	4.6	NS	NS	14.8	14.6	14.8

Black

	8/83	6/84	6/84	6/84	6/85	6/85	6/85	8/85	8/85	8/85
1	44.1	69.8	75.1	57.6	NS	NS	NS	65.4	65.6	65.1
2	15.0	18.7	17.8	16.8	NS	NS	NS	27.3	27.2	27.0
3	15.4	22.0	23.3	NS	NS	NS	NS	22.2	22.0	21.9
4	15.4	NS	NS	NS	NS	NS	NS	23.5	24.5	23.8
5	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Moxie

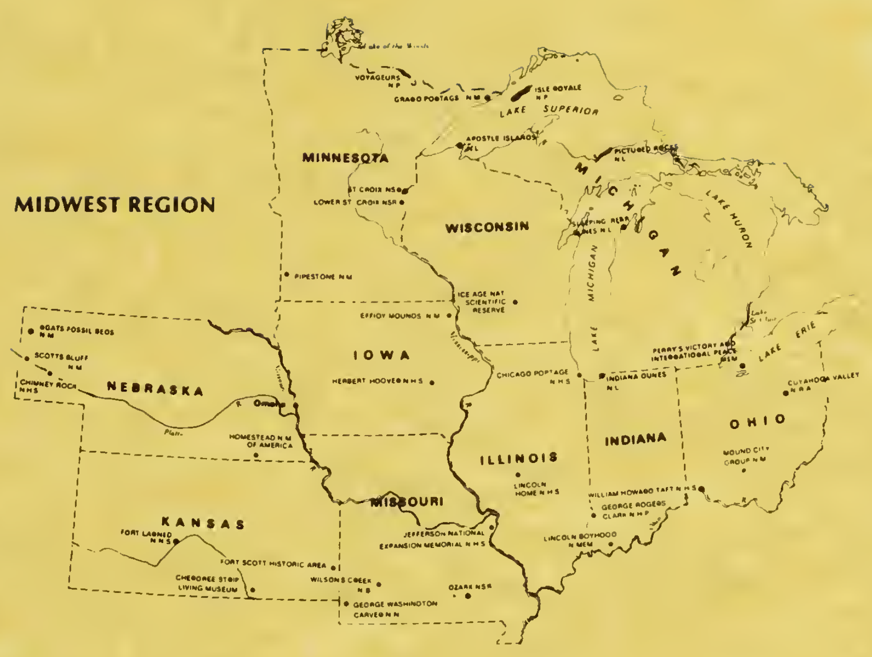
	8/83	6/84	6/84	6/84	6/85	6/85	6/85	8/85	8/85	8/85
1	2.8	54.6	7.3	3.5	3.0	NS	NS	3.5	3.7	3.4
2	49.8	59.2	59.8	58.9	4.1	NS	NS	17.3	18.6	17.7
3	28.6	52.4	53.9	55.5	16.4	16.0	16.7	45.4	44.0	46.1
4	21.8	53.0	54.2	54.5	57.3	NS	NS	63.4	62.5	61.6
5	30.5	58.5	56.9	56.4	60.0	59.8	NS	59.4	59.6	59.6

Junction

	8/83	6/84	6/84	6/84	6/85	6/85	6/85	8/85	8/85	8/85
1	10.8	8.4	7.9	7.8	22.3	NS	NS	28.5	28.9	28.6
2	3.4	14.2	13.8	15.8	11.3	NS	NS	4.6	4.3	4.4
3	16.5	16.7	20.8	17.4	16.3	NS	NS	11.2	10.3	10.8
4	8.4	6.5	6.1	5.5	16.1	NS	NS	5.9	6.0	6.0
5	1.4	3.7	3.0	3.5	3.6	3.5	3.8	3.5	3.0	3.4

Swanson

	8/83	6/84	6/84	6/84	6/85	6/85	6/85	8/85	8/85	8/85
1	31.3	63.5	67.7	66.6	53.5	NS	NS	83.8	84.2	84.2
2	30.0	43.5	43.3	43.0	4.0	NS	NS	48.6	48.7	49.0
3	16.0	23.2	30.8	32.1	36.0	NS	NS	24.7	24.1	24.5
4	43.0	NS	27.5	27.5	23.1	NS	NS	26.8	26.9	26.9
5	21.0	15.2	12.4	16.8	22.2	NS	NS	22.5	22.3	22.1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The National Park Service's Midwest Region covers 33 park units located in 10 states in the Great Plains and Great Lakes area (Nebraska, Kansas, Missouri, Iowa, Minnesota, Wisconsin, Michigan, Illinois, Indiana, and Ohio). The physical and biological diversity of the Region is reflected in the variety of research conducted in the parks. Current research subjects range from a survey of prairie vegetation in several small parks to the ecology of boreal forests at Voyageurs; from threatened plants in a number of parks to endangered wolves at Isle Royale; from hydrology of springs at Ozark to air pollution at Indiana Dunes; and from recreational boating use patterns on the Lower Saint Croix to hiking and campground use at Isle Royale. For more information on the National Park Service's Midwest Regional science program, please write:

Regional Chief Scientist
National Park Service
Midwest Regional Office
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March 3, 1849

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